

A MODEL FOR BENCHMARKING CONTRACTORS PROJECT MANAGEMENT ELEMENTS IN SAUDI ARABIA

By

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Dedicated to My Beloved Parents, Brothers

Who are the source of my inspiration, encouragement, guidance and happiness, and who share my goals and aspirations *May Almighty ALLAH Bless and Protect them.*

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All the praises and thanks be to Almighty Allah (SWT), the most gracious the most merciful, who gave me the knowledge, courage and patience to accomplish this research. May the peace and blessings of Allah be upon Prophet Muhammad (PBUH).

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THESIS ABSTRACT (ENGLISH)

Name : JUNAID AHCOM
Title : A Model for Benchmarking Contractors Project Management Elements in Saudi Arabia.
Major Field: CONSTRUCTION ENGINEERING AND MANAGEMENT
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The aim of this research is to develop a model to benchmark the organizational and working system of a construction contractor. This model will act as source of evaluation for new contractors, and assist the existing contractors to work on the areas of deficiencies.

The current research was focused to benchmark the organizational aspects of the project management elements: Cost estimation, Planning & Scheduling, Quality control, and the Safety management departments of a contractor firm.

The identified areas are benchmarked in two stages. Firstly through exhaustive review of relevant literature, successful organizational techniques being practiced by the industry leaders were scrutinized in a potential model. The organizational aspects emphasized here include: Key functions, Best location in the organization, Key personnel, Tools, Links with other departments, Manuals, Best Practices and other relevant aspects.

Further, in the second stage the model is reinforced to increase the significance. This was accomplished through the administration of questionnaire, seeking expert opinions from qualified professionals in industry and academicians from relevant area. Twenty one (21) professionals within the kingdom of Saudi Arabia contributed their opinions. The expert opinions were incorporated in the potential model to generate the final output.

Studies with similar objective have been recommended for all the elements associated with contractor firm, so that a comprehensive benchmark model can be developed.

THESIS ABSTRACT (ARABIC)

الاسم: جنيد أهكم

عنوان الرسالة: نموذج لتمييز عناصر ادارة مشاريع المقاولات في المملكة العربية السعودية.

التخصص: هندسة الإدارة والتصنيع.

تاريخ التخرج: مايو 2004

يهدف هذا البحث الى تطوير نموذج لتمييز تنظيم و عمل مقاول البناء. هذا النموذج سوف يعمل كمصدر تقييم لمقاولين البناء الجدد و سوف يساعد المقاولين الحاليين للعمل على تحسين نقاط الضعف.

تم التركيز في البحث الحالي على تمييز المظاهر التنظيمية للعناصر الادارية التالية للمشاريع: تقديرات التكلفة، ضبط الجودة، و أقسام ادارة الأمان لشركة المقاولات.

تم تمييز المجالات المعرفة على مرحلتين. أولاً من خلال مراجعة شاملة للبحوث ذات العلاقة تم تدقيق التقنيات التنظيمية الناجحة المتبعة من قبل شركات الصناعة الرائدة من خلال نموذج احتمالي. تتضمن المظاهر التنظيمية المؤكدة هنا على ما يلي: الوظائف الرئيسية، أفضل موقع في المنظمة، الاشخاص الرئيسيين، الأدوات، الوصلات مع الاقسام الأخرى، الكتيبات، أفضل الممارسات بالإضافة الى العديد من المظاهر ذات العلاقة الأخرى.

في المرحلة الثانية تم تدعيم و تعزيز النموذج المتبع لزيادة أهمية دلالاته. تم تحقيق هذا الهدف من خلال ادارة استبيان للحصول على اراء متخصصة لمجموعة من الخبراء المحترفين والمؤهلين من حقول التخصصات ذات العلاقة في المجالين الصناعي و الأكاديمي. شارك في هذا الاستبيان واحد و عشرون (21) من المتخصصين في المملكة العربية السعودية. تم دمج أراء الخبراء في النموذج المتبع للحصول على النتائج النهائية.

تمت التوصية بدراسات ذات اهداف مشابهة لكل العناصر المرافقة لشركات المقاولات وذلك لتطوير نموذج تمييز شامل.

CHAPTER ONE

INTRODUCTION

1.1. Introduction

In this modern world, daily life is maintained and enhanced by an impressive array of construction, awesome in its diversity of form and function. As long as there are people on earth, structures will be erected to serve them (*Clough & sears 1994*).

The first oil embargo occurred in 1973, which had a dramatic impact on the distribution of world's wealth. Much money flowed into the Middle East, which paved way for revolution in its construction industry (*Carty G.J, 1995*). In the Arab world, where investments in construction vary enormously from country to country, the share of construction in total investments is generally high and near 60% (*zahlan.A.B, 1984*).

Saudi Arabia is one of the most promising developing countries in the Middle East and the entire world. The Kingdom has experienced a massive construction program since the oil boom in this part of the world. During 1980 to 1990 the Saudi Arabian Government spent approximately SR 1,251 (\$334) billion on facility-construction activities (*Year statistical book 1400-1410H*). The Saudi construction industry is the largest economic sector in the Kingdom after the oil industry.

Saudi Arabia's continued economic growth and steady oil prices have kept the construction industry strong, which has resulted in a continuous high demand for building products and accessories. Construction contracts increased from \$2.65 billion in 1999 to \$3.35 billion in 2000 (*US-Saudi Arabian Business council, 2002*).

To some extent, every construction project is unique, and no two jobs are ever quite alike (*Clough & Sears, 1994*). The core of the construction industry consists of designers and construction contractors. The central organizing agencies in construction are the consulting and contracting firms (*Zahlan.A.B, 1984*).

A contractor is the business firm that will be in contract with the owner for the construction of the project, either in its entirety or for some specialized portion thereof. It is the party, which is supposed to bring together all of the diverse elements and inputs of the construction process into a single, coordinated effort (*Clough, 1994*). The efficient functioning of this party depends to a greater extent on its organizational and managerial working system of all the factors associated with it, particularly the project management elements of Time, Cost, Quality Control, and Safety. *Kuprenas et al.* (1999) articulated that while project success is influenced by a variety of factors, in all practical cases, successful project management will improve project quality while helping to maintain project budget and scope.

1.2. Statement of the Problem

With the boom of construction industry since the early 70's, Saudi Arabia is heaven for construction industry. This high demand for construction work attracted many investors to the construction industry, from all around the world as "Construction Contractors". These construction contractors hailing from different regions are by in large alien to the requirements of Arab construction industry, which is largely surrounded by desert.

In an industry severely challenged to provide adequate manpower at both the tradesperson and management levels in the coming decades, it seems imprudent to ignore the need to professionalize and legitimize the construction industry (*Alter K & Sims B.L, 2001*). Any contracting/Consulting firm needs to obtain official license to practice construction in Saudi Arabia.

According to the Saudi Arabian NCB Economist, 2002 and Ministry of land, Infrastructure and Transportation in Japan, 2001 "www.mlit.go.jp", following are the recognized Construction force practicing in the kingdom:

- Number of practicing Construction Contractors in the kingdom by the year 1993 were **12,018**
- Number of construction workers (2001)

Number of construction workers were > **One million**

Construction workers / Total working population were **14.4%**

As per the report published in "Al-Eqtisadiah" news paper No. 3732, 2003; there are total of 130,000 registered contractors in Saudi Arabia, but only 25,000 of them are currently practicing in construction business. The rest of the contractors are out of the business most of time for some reason, though they still hold the license.

These statistics suggest the serious need to comprehensively legitimize, standardized and benchmark the construction industry and especially contractors, who constitute the heart of the industry.

Ministry of commerce & Industry holds the power to license and legitimize any contractor firms in Saudi Arabia, where as Ministry of Public works & Housing legitimize and gives approval for government works. The criteria put forth by these authorities are very shallow and relaxed, which may lead industry susceptible to inefficient contractors who may not deliver as required (*Al-Eqtisadiah*, No.3732).

The Saudi Arabian *Ministry of Public Works & Housing* considers the following aspects of the construction contractor as their standard qualifications;

- Financial stability.
- Management staff capability.
- Manpower availability.
- Previous experience.
- Equipment availability.
- Contractor organization and scheduling techniques. (*Al-Gobali*, 1994)

But, unfortunately the standard qualification requirements put forth by these authorities for the government and Private construction work are relatively inadequate and

relaxed. Moreover these criteria's focuses on the risk of the contractor's failure and the contractor's ability to cover losses. Thus, the analysis performed by the MPWH & Ministry of Commerce & Industry is more financially oriented and less emphasis is placed on legitimization requirement (*Al-Gobali, 1994*).

These incompetent practices pose a serious risk and problems like

- Delays in meeting project duration
- Increase in total cost of the project, resulting in Bankruptcy of companies.
- Descend in construction quality
- Serious question on public safety
- Overall project failure

These incompetent and inexperienced practices by the contractors are causing serious damage to the quality of gigantic construction market in the kingdom. This situation is seriously demanding criteria for defining and Benchmarking a profound and competent Contractor, who can match the requirements of the construction market of Saudi Arabia. Those arguing in favor of this "Benchmark Contractor" cite public safety, quality control, cost, and industry integrity as primary reasons to institute kingdom wide definition criteria.

Considering the importance of benchmarking the contractor in the Kingdom of Saudi Arabia, there is need for research in this area. The following are commonly raised

Research Questions:

1. Why there is need for standard contractor?
2. What is a Benchmark construction contractor?

3. What are the components & requirements of these Benchmark contractors?
4. Are there any Benchmark contractors in Eastern Province of Saudi Arabia?
5. What are the deficiencies with contractors in Eastern Province of Kingdom?
6. What are the procedures and measures to be adopted to overcome the defects?
7. How are the contractors in Saudi Arabia doing with the four specified functions proposed to be studied?

1.3. Research Objectives

1. Defining and benchmarking the organizational aspects of four project management elements, namely Cost Estimation, Planning and Scheduling, Quality Control and Safety accepts of construction contractor from Literature review.
2. Reinforcing the benchmark contractor developed from literature, via expert opinion from Industry professionals and Academicians.

1.4. Significance of the study

A successful construction program can be achieved if the contractor organizational aspects and other requirements are comprehensively analyzed and defined before awarding the contract to a qualified, in broad words a “Benchmark Construction Contractor”

This research is aimed at defining and benchmarking the organizational aspects of Cost Estimation, Planning & Scheduling, Quality Control, and Safety departments of a

construction contractor in Saudi Arabia. A Benchmark contractor is the one who is well organized in all the aspects of construction and meets the challenges & necessities to accomplish a given project as per the signed contract and specifications.

This classification of standard construction contractor specifies the abilities and specialties of the contractor and his financial, organizational and managerial condition. The aims of classification are to develop and state the ability to operate in the contracting fields of construction, maintenance and operation, by classifying contractors according to their scientific experience, technical, organizational, managerial and financial ability. The specialty of contractors and degree of classification is defined in a way that guarantees the successful execution of contracts, both for the owner and contractor. It prevents the contractor entering into contracts beyond his capabilities and disputes arising between contractors and owners due to the lack of ability to perform according to the terms and requirements of the contract documents.

1. By standardizing the specific functions of contractor from the extensive literature review and subsequently evaluating the same with the current individual contractor professionals in the Eastern province of Saudi Arabia and with qualified academicians from two renowned universities in the kingdom, will help to develop a model defining requirements of contractor in the Kingdom.
2. The findings of the research will give opportunities to work on areas of deficiencies.
3. The study will benefit most of the construction contractors and will be a source of evaluation for the new contractors.

4. The study will also serve as an educational tool for academia.

1.5. Scope and limitations

This research study would deal with benchmarking the organizational aspects of contractor's project management elements of Cost Estimation, Planning & Scheduling, Quality Control, and safety, in the kingdom of Saudi Arabia. This study considers by in large all the construction contractors types, irrespective of size.

The research comprise of the extensive survey of the literature concerning the contractor's organization aspects for aforementioned areas. The major source of information for bulk of the research data is through literature study.

For reinforcement of potential model, expert opinions from industry professionals and academicians were obtained. Selection criteria concentration was industry professionals from the Eastern Province for convenient approach to every professional at the site for better comprehension of scenario in reality and for precise and comprehensive data collection. Eminent Construction contractors from the major cities of Ad-Dammam, Al-Khobar and Dhahran will be given primary preference in this research. The limitation of contractor selection to Eastern province is also justified due to time and cost constraints and also because of the fact that construction industry in Eastern Province is by in large accepted to be in consistency with the whole Kingdom.

Experts from Academia are selected from the two prominent universities in the kingdom. For getting experienced opinions, highly qualified academicians are carefully scrutinized and selected for the study.

CHAPTER TWO

LITERATURE REVIEW

2.1. Introduction

The extensive literature study is one of the most important phases in the methodology of this research. The primary aim of the detailed literature study is to acquire the comprehensive knowledge about the subject under study, "organizational aspects of contractor's project management elements".

The comprehensive study in this chapter will attempt to answer the queries:

1. Who are the key participants in the construction business?
2. Why is the need to standardize contractor organization?
3. What are the project management elements, organizational aspects of these elements?
4. What are the organizational aspects or cost estimation, Planning & scheduling, Quality control, and Safety management departments as identified from previous studies

The findings from this chapter would serve as key source for developing the potential model to "Benchmark: Organizational aspects of contractors project management elements"

2.2. Key Participants in construction

Construction process requires the application of a diverse range of resources to recognize a finished facility. The organization and application of these resources can be viewed in terms of the level and authority by which decisions and management is being made. This explicates the importance of a qualified builder. “In the ancient time the “master builder” had full responsibility for all phases of a project including engineering, aesthetic design, plan preparation drafting and construction” (*Kumaraswamy, & Palaneeswaran* 2000)

The primary contributors in construction process are:

- ✓ The Owner
- ✓ The Architect-Engineer
- ✓ The Contractor or constructor

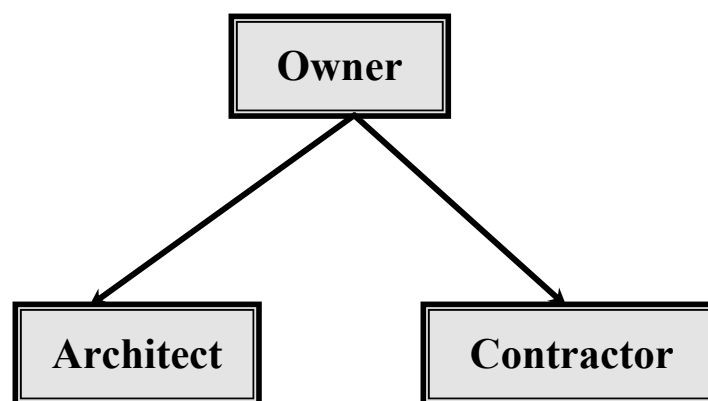


Figure 2.1: Key Participants in Construction

The Owner

Owner organizations can generally be divided in to public owners and private owners (*Carty & Fellow*). The owner is the instigating party for whose purposes the construction project is designed and built (*Clough & Sears*).

Clough & Sears, (1994) articulated that Public owners range from agencies of the government down through state, country, and municipal entities to a multiplicity of local boards, commissions, and authorities, Whereas private owners may be individuals, partnerships, corporations, or various combinations thereof.

The Architect-Engineer

The architect-engineer, also known as the design professional, is the body, organization, or firm that designs the project. The architect-engineer can occupy a variety of positions with respect to the owner for whom the design is done (*Clough & Sears*, 1994).

According to dictionary, An architect is the one who has completed a course of study in building and design, served an internship and passed a test and is licensed by the state as an architect.

Carty (1995) states that architect-engineer is the second major participant in the construction process. He also states that where building work is involved, an architect usually leads the design team.

The Contractor or Constructor

A contractor is the company licensed to perform certain types of construction activities (*Ronald B*, 2003).

Carty (1995) states that contractor is the third major participant in the construction process. *Clough* (1994) articulates that a contractor is the business firm that is in contract with the owner for the construction of the project, either in its entirety or for some specialized portion thereof. He is the party, which is supposed to bring together all of the diverse elements and inputs of the construction process into a single, coordinated effort.

In the current era, construction contracting companies are the authorities responsible for organizing and managing the different levels of work involved in construction process. They are accountable to effectively bring together planning and design, analysis, and control measures to realize the end item, the facility. For bringing the above elements together the contracting authority should be very well qualified and satisfy the yardstick requirements.

Clough (1994) further states that the essential function of the contractor is close management control of construction. The key contribution of the contractor to the construction process is the ability to marshal and allocate the resources in order to achieve completion at maximum efficiency of time and cost.

2.3. Types of Construction Companies

Following are the chief types of construction companies, operating conventionally in the industry.

- ✓ General Contractor
- ✓ Design Construct Contractor
- ✓ Construction Manager (construction management)

General Contractor

General contractor is party responsible for the execution, supervision and overall coordination of a project and may also perform some of the individual construction tasks.

Carty (1995) articulated general contractor is a company that performs construction work on a fixed-price basis and has sufficient resources to accomplish the work successfully. A construction project presents the contractor with many difficult management problems. The skills with which he marshals the allocated resources serve his own interest as well as those of the project owner.

Design Construct Contractor

A design construct contractor performs both the design and construction of a project. Until more recent times, design-construct contracts were reimbursable form of contract and were used for big projects.

Construction Manager

Construction management is a term that is applied to the providing of professional management services to the owner of a construction project with the objective of achieving high quality at least possible cost and time (*Clough & Sears*, 1994).

According to *Fisk* (1997) a construction manager cover broad range of services and to some extent, overlie those traditionally performed by both the architect/engineer and the construction contractor, involving the design as well as construction phases of a project. Construction manager in some cases provide certain services that would normally have been provided by a general contractor, if there had been one.

Construction management is the body which is recognized of having advantages, if involved right from the start of the project. In many instances now, the construction manager is hired about the time the engineer or architect is engaged, he provides input to the design, offer ideas to make design more effective and economical. The construction manager develops a schedule and budget during the early stages of design (*Carty & Fellow*, 1995).

2.4. Organization of construction firms

According to *Carty and Fellow* (1995) there are three main departments of construction companies, under the chief executive officer are as under;

- Operations

- Engineering and Estimating
- Administration

Operations

This department is responsible for overseeing the actual construction work being performed in the field. Generally the executive responsible for this function would oversee several construction managers and so on to accomplish the task successfully.

Engineering and Estimating

Construction estimating is the compilation and analysis of the many items that affect and contribute to the cost of a project (*Clough & Sears*).

Construction costs are estimated to serve a variety of purposes, and much of the credit for the success or failure of a contracting firm can be ascribed to the skill and capabilities of the estimating authorities.

The function of this department is to receive the bid documents for a project and carry out in-depth analysis of the risks and cost of the project. Preparing the cost estimate entails the take off of quantities of work and pricing the work and to be performed by the contractor, soliciting, receiving and analyzing subcontractor bids, assembling the entire estimate, and submitting the bid to the owner.

Administration

The Administrative department includes payroll, accounting, and financial functions. This department is headed by a comptroller or chief financial officer.

Administration is noting to do much with engineering, but is very essential for a successful construction company to have the excellent capability in this area.

2.5. Impetuses behind Benchmarking or Standardizing the Contractor

The stated goal of defining a Benchmark contractor is to “raise the standards of the practice of the constructor, thus benefiting all parties involved in the construction practice, including peoples.

Alter and Sims, enlighten that the Impetuses or the driving force behind the need for certifying or qualifying or benchmarking a contractor as defined by American Institute of Construction (*AIC*, 1994)

1. Increasing specialization of construction processes and organizations.
2. The need for closer coordination and cooperation
3. Owners placing more emphasis on management skills, service delivery and the execution of projects by demanding better performance, productivity and quality in the construction process.
4. More involvement by construction contractors in direct consultation with project owners.
5. A more diverse work force.
6. Increasing governmental regulation with regard to working conditions, hiring practices and safety.
7. Decreasing profit margins throughout the industry.
8. Increasing the complexity of the construction project.
9. Declining image of construction work and workers.

10. Need for implementation of new technologies in the construction process.

2.6. Benchmarking: Organizational Aspects of Contractors Project Management Elements

Project management is defined as the systematic application of management and construction expertise through the planning, design and construction process. A contractor's managerial experience indicates his knowledge and capability for handling the project in the most proper fashion.

Kuprenas et al. (1999) articulated that while project success is influenced by a variety of factors, in all practical cases, successful project management will improve project quality while helping to maintain project budget and scope.

The Project management constitutes important parts of construction firm, as it organizes, plans, schedules, and controls the fieldwork and is responsible for getting the project completed with in the time and cost limitations (*Clough & Sears, 1994*).

Clough (1994) expressed that if a project is to meet its established time schedule, cost budget, and quality requirements, careful management monitoring of field operations is a necessity. He further states that construction projects are one-time and largely unique efforts of limited time duration which involve work of a nonstandard zed and variable nature which demands project management.

Martel and Moselhi (1988) articulated that traditionally, the goals of project management have been to establish balance between schedule, cost and quality, but to act for prevention and the steadily rising cost of workers compensation premiums, contractors must include safety as integral part of project management. Figure 2.2 depicts the Project management quadrilateral.

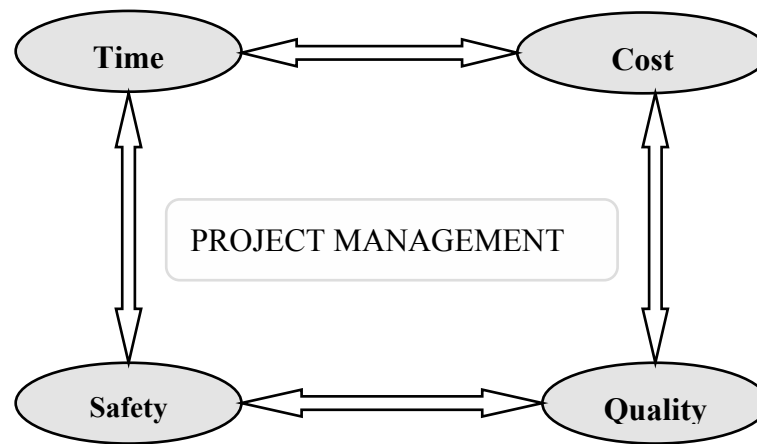


Figure 2.2: Project Management Quadrilateral

The following sections present the comprehensive study of the organizational aspects for the contractor departments in the four aforementioned areas.

2.7. Cost Estimation Department

2.7.1. Introduction

Cost Estimating is one of the most significant aspects for proper functioning of any construction company. It is the lifeblood of the firm and can be defined as the determination of quantity and the predicting or forecasting, within a defined scope, of the costs required to construct and equip a facility.

The significance of construction cost estimates is highlighted by the fact that each individual entity or party involved in the construction process have to make momentous financial contribution that depend in largely on the accuracy of a relevant estimate (*Adrian. J; 1984*).

The importance and influence of cost estimating is supported by scores of researches. *Carty* (1995) and *Winslow* (1980), for example, have documented the importance of cost estimating, mentioning it as a key function for acquiring new contracts at right price and hence providing gateway for long survival in the business. To *Larry, D. et al.* (2002) cost estimating is of paramount importance to the success of a project. Further, from the contractors view angle, accurate estimating is of large importance, the profit margin of the contractor depends on the accuracy of his or her estimate.

Similar to a project owner, the construction contractor is hugely dependent on the competent preparation of estimates. Unlike other manufacturers who determine product

cost from data after it is finished, a construction contractor is supposed to give the owner client a price much before the total production costs can really be known (*Adrian. J*, 1984).

Project cost estimate is the combination of all the cost, from the scratch that will be incurred on the construction of any particular project. It includes all the direct and indirect costs, comprising direct labor, material, equipment, engineering and also other costs like various overheads, interest, contingencies and profits. In his study *Clough* (1994) mentioned that cost estimating is the collection and analysis of the many items that influence and contribute to the cost of a project. Cost estimating task is accomplished before the physical performance of the work, it requires detailed study.

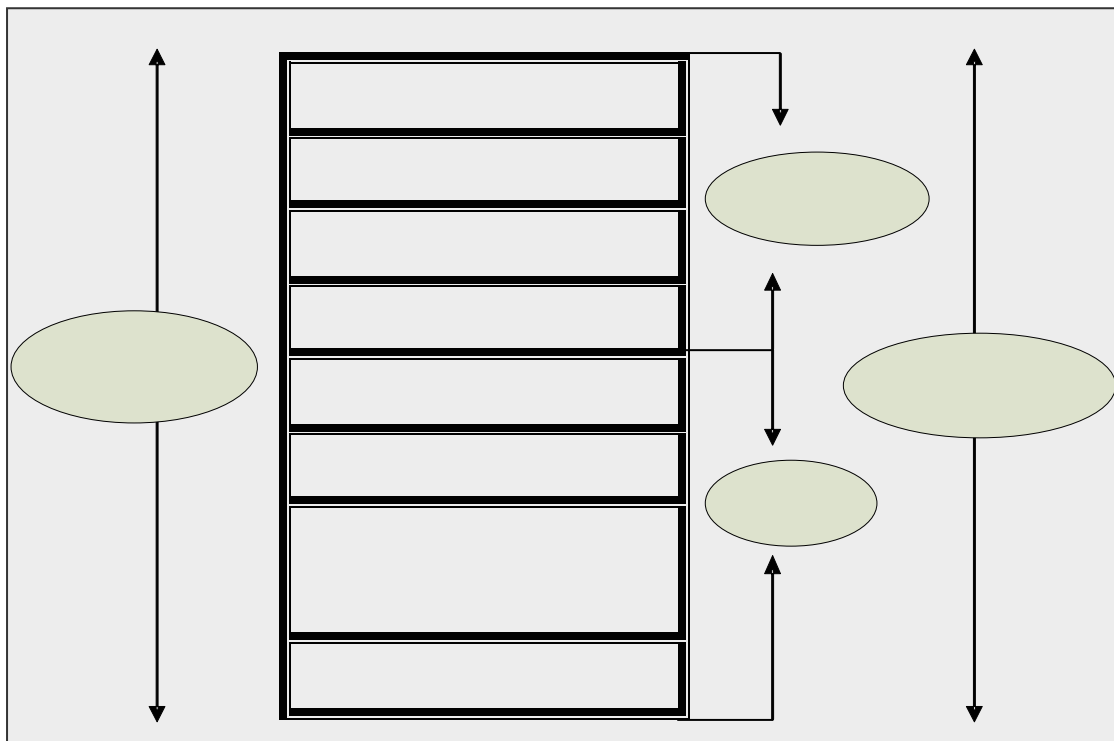


Figure 2.3: Components of Project Cost Estimate (Ostwald. P.F)

As per project management body of knowledge, cost estimates are the final outputs as result of various inputs inclusive of work breakdown structure, resource requirements, historical information, resource rates etc. using various estimating practices as the tools & techniques. According to *Duncan William R*, (1996); cost estimating involves developing an approximation of the costs of the resources needed to complete project activities. When a project is performed under contract, care should be taken to distinguish cost estimating from pricing.

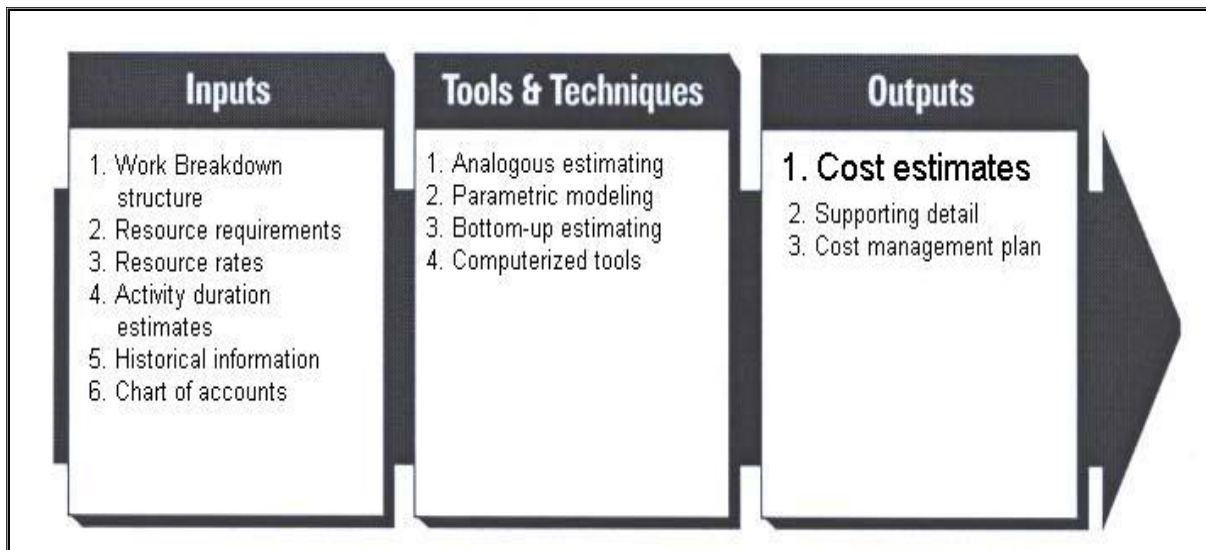


Figure 2.4: Inputs and Techniques to get cost estimates (Duncan William R.; Project Management Body of Knowledge)

2.7.1.1 Where Cost Estimating Position in the Organization

In the language of construction industry, the individual in command of the engineering and estimating department is usually termed as the chief engineer. Under the

chief engineer will be the project manager leading the group of engineers and directors of other departments (*Clader. G*).

The primary function of the cost estimating department is to receive the bid documents for a project and do a required meticulous, in detail analysis of the risks and cost of the project. *Carty* (1995) documented that, preparing cost estimate entails the takeoff of quantities of work to be accomplished by the contractor; requesting; receiving; and analyzing bids; assembling the complete estimate; and submitting the same to the owner.

Alcables, AACE; articulated that, estimating department will be answerable to the chief executive. Subsequently with in the estimating department, under that supervision of the chief estimator is responsible for the preparation of all estimates, estimating procedures, pricing information, check lists and applicable computerized programs.

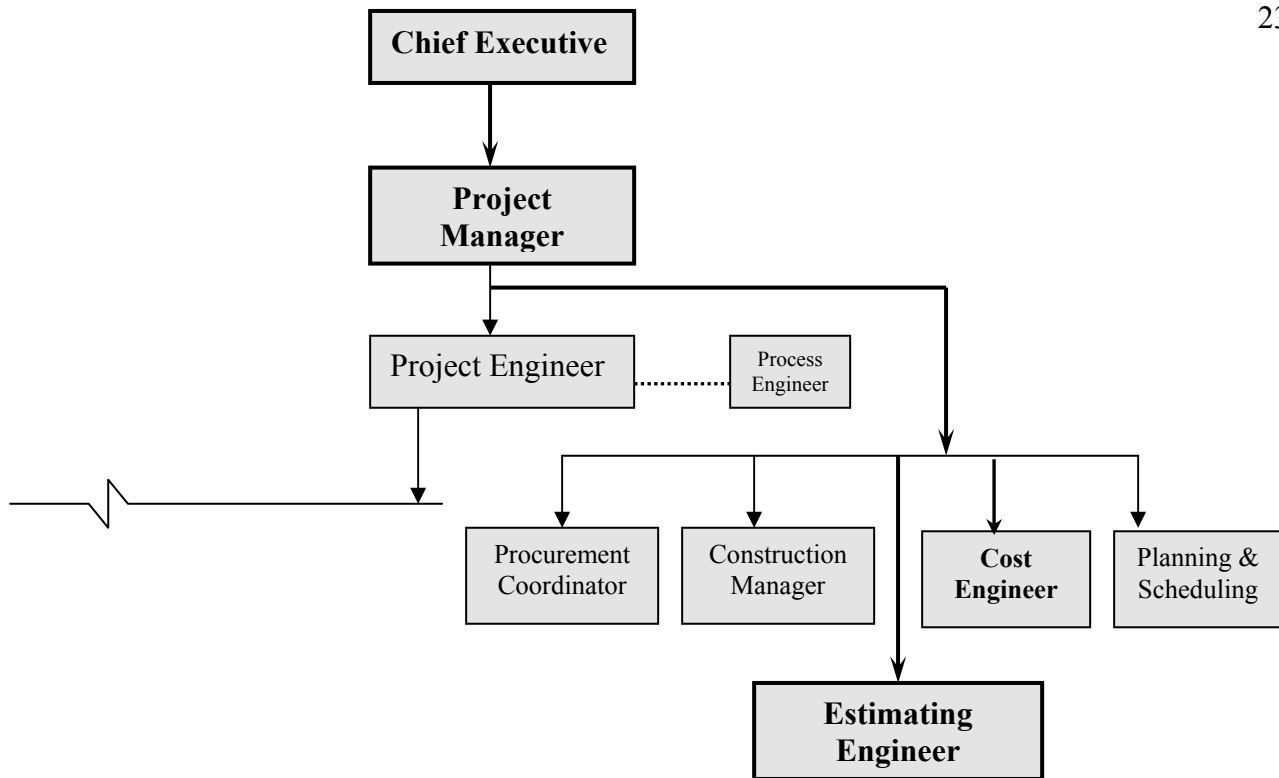


Figure 2.5: Example management organization showing the suggested position of Cost Estimating department

2.7.1.2 Requisites of Good Estimator

Construction cost estimator can be defined as an individual who, prepares preliminary and final construction cost estimates for various kinds of construction, alteration, and demolition projects including buildings, roads, flood control facilities, landscaping, and related public works projects to be utilized as a basis for determining engineering feasibility and economy.

The successes or failure of a project is to large degree, reflected by the estimator's skills and experience. An estimator's skills enable him to organize the estimate and

exploit the latest and most accurate techniques in preparing costs (*Kitchens. M*, 1995). It is duty of any successful contracting organization to ensure its future through careful selection and training of estimators.

Following are some of the provisos essential in the making of a good estimator (*Kitchens. M*, 1995):

- Superior aptitude for mathematics through basic math.
- The ability to read and comprehend plans, specifications and other bid documents
- Detailed knowledge of latest construction techniques and changing job conditions.
- The skills to mentally visualize the various phases of the construction projects and price the job accordingly.
- Knowledge of costs for labour, equipment, material, transportation and other services.
- Experience in the kind of work being estimated or the ability to draw from the experience of others.
- Familiarity with functions of purchasing and expediting
- An above-average amount of common sense.
- Familiarity with contracting with owners and subcontractors.
- Education through training and experience.
- Capability to use computers and the software available to the estimating functions.

2.7.2. Organization of Estimating Department

Organization of any department requires question and review of many factors. Organization of cost estimating department requires question of various factors including contractor's degree of specialization or on the other hand, how diversified he might be, whether the activities involved are localized or widespread, and also the size of the business (*Frein J.P*, 1980).

The estimating department will administer, appraise and control the estimating function and participate with marketing and management in reviewing inquiries from prospective clients (*Alcables*, 1988).

Frein J.P, articulated the as the size and dimensions of the construction firm increases, the costs estimating function is invariably entrusted to specialists and peers in the field. As the task becomes complex and demanding a greater degree of knowledge and expertise becomes essential.

Clearly it can be understood that there can be no preset principles for organizing an estimating department that can be generalized or applied to each of the contracting firm, except to do so on the most efficient and economical basis. Principally there are no universally accepted rules in the different estimating techniques for medium-to-large size, and well diversified contracting organizations, but there can be set procedures scaled down to fit smaller firms.

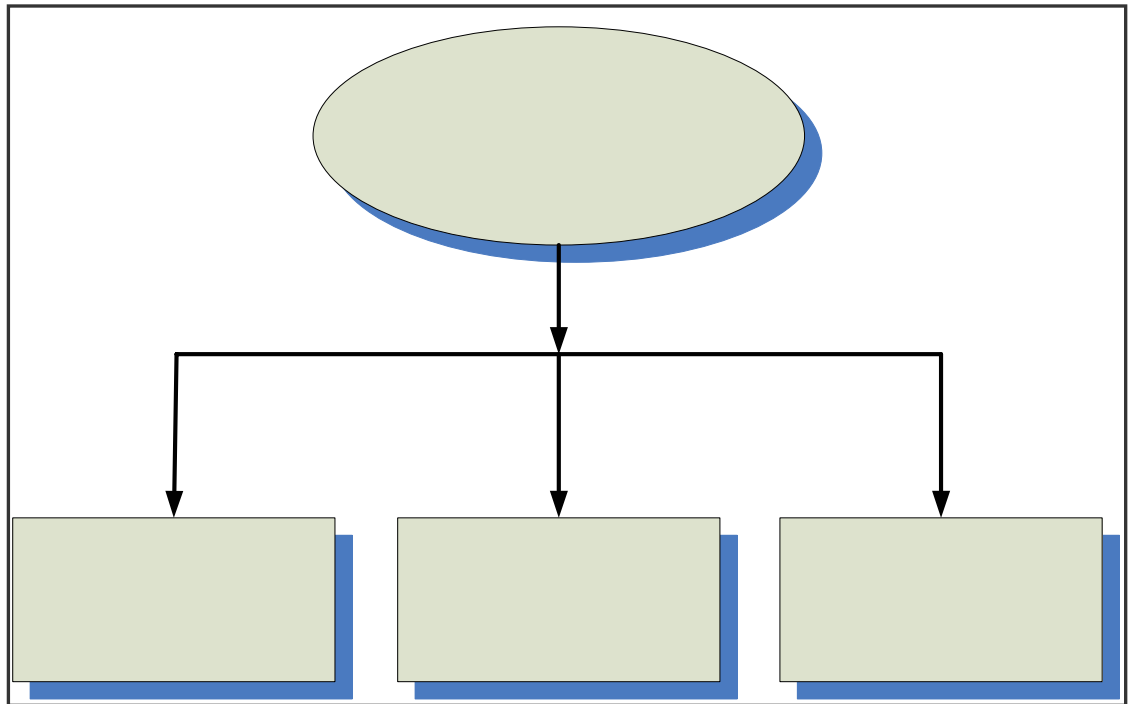


Figure 2.6: Organization of Cost Estimation Department (*Frein J.P*, 1980)

2.7.2.1 Quantity Survey and Take-off Work

Quantity survey is a technical procedure for estimating the cost of a new construction; it involves detailed estimates of the quantities of raw materials to be used, the current price of the materials, and the labor costs. It is also known as the price takeoff method

Adrian. J, articulated that quantity take-off is one of the most essential and highly important aspect of the contractor's estimating and bid functions is taking off of work quantities from the drawings of the project.

Quantity survey and take-off work are secondary function to the estimating or actual pricing. In case of firm-price, lump-sum contract, accuracy of these functions is essential as it establishes the amount of work to be priced and for which payments will ultimately be received (*Frein J.P*, 1980).

Small construction organizations often tend to discount control in favour of marketing or production; this often results in lack of controls regarding preparation of an estimate and bid (*Adrian. J*,1982). Internal controls including maintaining footing take-off sheets and having some assistant other than the individual who prepares them check take-off extensions can prevent a significant estimating error that could expose the equity of a contractor.

Vital to the quantity take-off function is the identification of specific packages of work referred to as work items. The estimator will have his own freedom in defining specific work items for a given project.

According to (*Frein J.P*, 1980) following has to be taken care about Quantity Takeoff work for and efficient running of a cost estimating department:

- Take off work requires a fine understanding of the tender documents. This is particularly important in case of plans and specifications, which tend to become more technical as work goes on.
- Take off work should be done in such a way that the computations can be subsequently followed for certification.

- Computation sheets should have details including the date and initials of individual working over it, they should include brief description of the part involved with dimensioned sketches, plans and specifications references.
- Take off work be required to be planned and performed to fit the plan for pricing the item in question, the estimator will be need to direct the takeoff work, if he doesn't perform the same himself.
- Drafting and miscellaneous engineering calculation and design are usually part of the takeoff job and are performed by the same individuals.

2.7.2.2 Selection of Estimating Personnel

According to *U.S Department of labor (2003)*, Correctly forecasting the cost of future projects is vital to the survival of any business. Cost estimators develop the cost information that business owners or managers need to make a bid for a contract or to determine if a proposed new product will be profitable. They also determine which endeavors are making a profit.

A highly knowledgeable personnel with broad set of both technical and nontechnical skills is prime need of every effective estimating organization (*Dysert L, Bruce G, 2000*). Individuals who price construction projects must be temperamentally suited, honest, and experienced in the work involved in the estimating process. If the estimator is not very experienced in the job, he at least he is expected to be competent construction engineer skilled enough for accurate analysis of construction problems as a whole (*Frein J.P, 1980*).

Dysert L, Bruce G, 2000 extensively articulated about the chief “estimating core competencies”, namely business skills, software skills, communication skills, and general skills. They further stated that, efficient documentation of these core competencies is important for estimators to understand the basic skills required to perform effectively in their position, and is also important for estimator’s recruiting purposes.

Business Skills:

- Effective understanding of the project process;
- A meticulous insight of the estimate requirements for each class of estimate;
- Ability to interpret engineering documents;
- Code of accounts or work breakdown structures;
- Skills of basic project controls (budgets, schedules, forecasting, cost control, etc.);
- Ability of data analysis (labour productivity, benchmarking, etc.);
- Strategic estimating skills including, equipment factoring, cost modelling, capacity factoring, etc.); and
- Efficient skills of detailed estimating like, material takeoffs, pricing and costing.

Software Skills:

- Compatible software system (accounting system, purchase order system, material pricing system, timecard, and project charging systems);
- A range of diverse and all-purpose software's (Excel, word, powerpoint, Lotus notes, Etc.);
- Estimating Software (all estimating software's used by the hired department)
- Estimating workload reporting system;
- Risk analysis software; and
- Programming skills;
- Project historical retrieval and analysis system.

Communication Skills:

- Presentation Skills;
- Report writing; and
- Listening and communicating.

General Skills:

- Planning, organizing, and delegating;
- Resourcefulness and problem-solving;
- Decision-making;
- Teamwork and relationships;

- Following project process and procedures;
- Leadership and negotiations; and
- Marketing.

According to *U.S. Department of labour*, for qualification of cost estimator In the construction industry, employers increasingly prefer individuals with a degree in building construction, construction management, construction science, engineering, or architecture. However, largely construction estimators are observed to have considerable construction experience, acquainted with work in the industry, internships, or cooperative education programs.

U.S. Department of labour, 2003, further states that cost estimators should have an aptitude for mathematics, be able to quickly analyze, compare, and interpret detailed and sometimes poorly defined information, and be able to make sound and accurate judgments based on there information. Assertiveness and self-confidence in presenting and supporting their conclusions are essential, as are good communications and personal skills, because estimators usually work as part of a project team next to managers, owners, engineers, and design professionals. Cost estimators also need knowledge of computers, including word-processing and spreadsheet packages. In some instances, familiarity with special estimation software or programming skills also may be required.

2.7.2.3 Estimating Training

Training of estimating professional is equally or more essential than the selection of estimating professional. Education and training is always important as it imparts the knowledge of the latest practices, happening and developments in the construction industry. *Dysert L, Bruce G, 2000*; expressed that extensive training is always fruitful and will be usually conducted for each estimator in lines with the estimator performance expectations and the estimating core competencies. The Estimator training phenomenon is summarized in a document called the employee development plan.

Despite of cost estimating professional's background, each estimator receive much training on the job because every contractor organization has its own way of handling estimates. Working with an experienced estimator, they get familiar with each step in the process. Those with little experience in understanding construction specifications or blueprints first learn that aspect of the work. They then may accompany an experienced estimator to the construction site. As they become more knowledgeable, more responsibilities are landed on there shoulders. (*U.S. Department of Labour, 2003*). Time to time informal training meetings will be scheduled for the entire estimating group on a monthly basis, these meetings will be proceeded by members of the estimating department. The informal training sessions are gradually supplemented by more formal lessons by outside training organizations (*Dysert L, Bruce G, 2000*).

2.7.2.4 Typical Estimating Organizations

Estimating function is broadly acknowledged to be an engineering responsibility and for that reason would come under the direction of the principal engineering officer of the contractor organization, presumably the chief engineer, in an overall capacity, or district or division engineers under the direction of the chief engineer for a firm with widely classified operations (*Frein J.P*, 1980).

U.S. Department of Labour, Frein J.P, articulated that it is presumed generally that the practices of an engineering office including head office are quite sufficient enough to support a regular estimating staff consisting of technical people to make the necessary quantity surveys, takeoff and the engineering studies, involving completion of standard estimating forms, filling in dimensions, number of units, and other information.. This group of estimating staff would be supervised by an officer engineer who would assign the work periodically and would coordinate it with all the estimators responsible for the final pricing. The office engineering group would look to the responsible estimator of each job to outline the form and detail in which the takeoff information should be prepared to fit the setup of pricing.

For the preparation of detailed estimates, a group of estimators would be always available as they may be required. They are picked for specific parts of estimates according to the particular talents of the estimator or for the coordination of various minor parts of estimates. It is generally observed that extensive the estimator's background, knowledge, and experience, however, the greater his value to an estimating group. The

chief engineering officer is in charge of evaluating the quality of estimating work being performed, if a particular problem is out of reach of the hired estimators, the engineer is expected to acquire an expert for the same.

Frein J.P., mentioned that it is commonly experienced that in the contracting field, cost estimators tend to develop capabilities and special skills along specific kinds of task's, namely buildings, heavy excavations, heavy concrete work, mechanical installations, plant and equipment design and pricing, tunnel and underground works, utility work, grading, paving and Etc. some estimators develop special talents in the evaluation of work abroad, it's the task of management to appoint the best person for the best task.

Contractor organizations of smaller size and specially those following specialized lines, will have less complicated estimating organizational problems. The owner of the business could do all or most the estimating, or he could appoint several estimators of proven qualities to perform it. The larger and more diversified a company becomes, the greater and sophisticated gets the job of organizing contractors estimating organization. In large construction companies employing more than one estimator, it is common practice for estimators to specialize. Usually, one may be employed to estimate only electrical work and another may concentrate on excavation, concrete, and forms (***U.S. Department of Labour; Frein J.P.***).

Managing the workload of a large group of estimators can be a complicated task. The individual workload assignment for the estimating staff needs to be monitored, as well as the advancement of all active estimates. Estimating department at Kodak uses a software application, the Workload Reporting System (WRS), to aid in managing the estimating workload (*Dysert L, Bruce G, 2000*).

Number of Estimators

It is a management decision on deciding upon the number of cost estimating individuals to be employed by a construction company. Usually the number of cost estimators in any firm, depend largely on its size.

In a construction company, the estimating staff may consist of **one** person if the company is small and the number of estimators can be **20, 30 or more** in case of larger construction firm. In the latter companies, there will be a number of senior estimators and they will be assisted by junior estimators and engineering aides (*Carty, 1995*).

According to **U.S. Department of Labor**, 2003, in the United States by the year 2000, around 211, 000 Cost estimators were employed, among which about 50 percent were in the construction industry. Cost estimators work throughout the country, usually in or near major industrial, commercial, and government centers, and in cities and suburban areas undergoing rapid change or development.

Construction cost estimators are also employed by the project's architect and owner to estimate costs or track actual costs relative to bid specifications as the project develops. In large construction companies employing more than one estimator, it is

common practice for estimators to specialize in specific fields. An estimator may estimate only electrical work and another may concentrate on excavation, concrete, and forms. Where as in smaller companies, most of the task may be carried on by the owner or he may employ several estimators.

Typical Operating Principles of Estimating Department

According to *Alcables*, AACE; following are some of the successful operation principles of a typical cost estimating department.

a. Prior to the start of the work on any estimate, the estimating department will assure that there is written authority and an adequate description of the work to be done, also there is adequate budget and schedule assigned for the preparation of the estimate.

b. Requests of several project managers for priority in estimating services are to be reviewed and decided upon by the chief estimator.

c. The estimating department must continuously analyze material and labor feedback to the end so that inaccurate estimating methods can be corrected.

d. The estimating department must continually work to develop and improve its estimating methods and techniques for use on estimates.

e. To make sure that estimating department is fully apprised of the technical details and scope of the work, the department itself will propose meetings and job progress meetings.

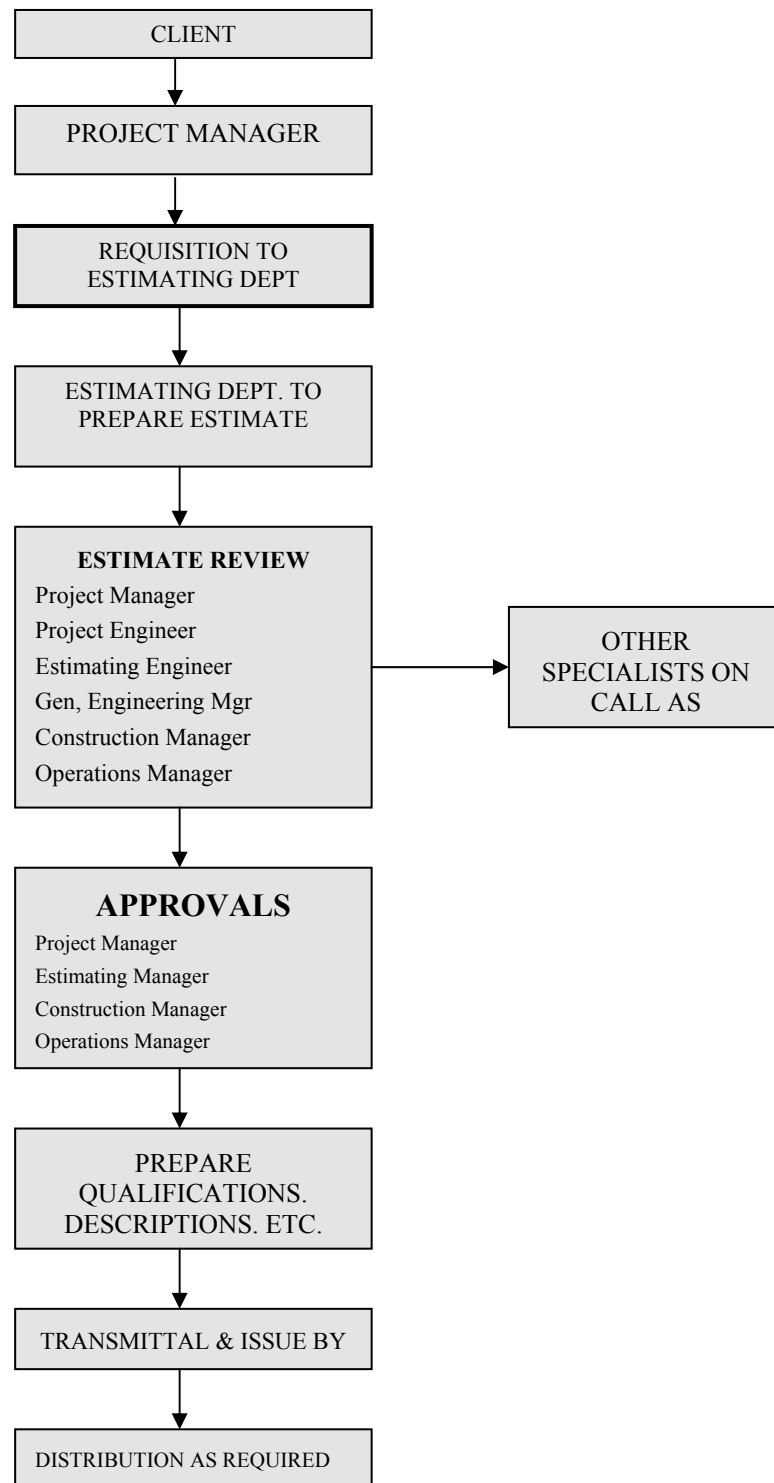


Figure 2.7: APPROVAL FLOW DIAGRAM FROM ESTIMATING DEPARTMENT (Redrawn, from Alcabes, AACE)

2.7.3. Estimating Manual

A firm with a multiple number of estimators and division should establish department estimating procedures, illustrating guidelines for preparing estimates and should determine their formats organized together called estimating manual. The manual should also include documented and maintained procedures under controlled distribution, as is end-user documentation for the software systems, and other resource information.

Page John. S, 1996; states that these time-honored manuals provide the tried-and-true information required for making the most thorough and accurate labor and cost estimates in the most efficient manner. These estimating manuals presents hundreds of man-hour tables which are product of hundreds of time and method studies conducted in the field and in the shop. As a result, these respected manuals and their tables provide company cost estimators with a dependable, proven basis for obtaining production efficiency percentages by applying all known local conditions and variables. These estimating manuals also allow the estimators to obtain direct labor rates for the crafts involved.

The Estimating procedures manual contains the following sections (*Dysert L, Bruce G, 2000; Frein J.P):-*

- Overview of the estimating process;
- Review of estimate requirements;
- Planning the estimate;
- Structuring the estimate;

- Developing the estimate;
- Analyzing cost risk and estimating contingency;
- Documenting the basis of an estimate;
- Estimate reporting;
- Review and issue estimate (including benchmarking analysis);
- Estimate maintenance (change management)
- Estimate close-out (project close-out support); and
- Estimate databases and systems maintenance.

The Estimating procedures manual will facilitate to do the following (*Dysert L, Bruce G, 2000; Frein J.P*):-

- Assist in the training and guidance of estimating engineers.
- Serve as a key check list and guide to estimating engineers making site jobs.
- Set up a step-by-step guideline for estimating, forming a format which will be easily read and followed by estimators of the firm.
- Minimize the efforts required to supervise the preparation of estimates.
- Direct the project engineers and others on the work in the preparation and interpretation of company estimates and cost reports.
- Assist in establishing the cost-accounting breakdown for new work for the benefit of all concerned.
- Direct the cost estimator on to the proper breakdown of costs to parallel the established company accounting system.

- Assist in summarizing various parts of the estimates into their various elements for analysis and evaluation with other estimates.

2.7.4. Information Technology in Estimating / Computer-aided estimating:

The use of information technology expectedly adds extra fuel to the cost estimating department, computers ability of data capture, manipulation and retrieval in massive databases and less mathematically rigorous methods of analysis helps tackle complex estimating problems. *Smith. N, 1995*, mentioned that primary function of computer aided estimating technique is to facilitate data retrieval and transfer, in performing data manipulation, to speed up calculation, and to produce quick reports.

Ahuja et al. (1994) articulated that major part of construction estimating is still performed manually, augmented perhaps with spreadsheets and templates to facilitate calculation and organization. But it has been noticed that with the rapid advance in computer use, the use of software packages has improved rapidly in recent years. The large array of estimating software packages including (*Suhanic, 1998*):

▪ Timberline Software Corporation Medallion System
▪ Bid Master
▪ SoftCOST
▪ CONAC Group
▪ WinEstimator
▪ Others etc.

Construction cost estimating, by its very nature, is an experience-based process that depends more on the competence of the people involved than on any procedure or tool. Despite the propagation of computerized estimating tools (43 packages identified in a survey conducted by *Arditi et al.* 1991), several researchers have reported that little has been added that can be considered state-of-the-art during the past decade (*Hegazy T. and Moselhi.O*; 1995)

According to *U.S Department of labour* (2003) Computers play an integral role in cost estimation because estimating often involves complex mathematical calculations and requires advanced mathematical techniques. Although computers cannot be used for the entire estimating process, they can relieve estimators of much of the labour associated with routine, repetitive, and time-consuming calculations. Computers also are used to produce all of the necessary documentation with the help of word-processing and spreadsheet software, leaving estimators more time to study and analyze projects.

A variety of estimating techniques and estimating software is employed in preparing the many classes of estimates. Along with the competent estimating system, estimators are also expected to need access to word processing and spreadsheet software (*Dysert L, Bruce G, 2000*). Among the various costs estimating software employed, the Timberline software is one of the most prominent one, it is precision estimating software which is PC-based and available from timberline Software Corporation. Timberline is first of its kind Commercial Knowledgebase which gives you ready to go models also supported by RS Means pricing.

According to (*Smith N, 1995*), for proficient estimating outputs, any computer software must incorporate certain key basic functions including:

- A data library for storing item or resource data
- An array of techniques for adding to the direct costs to produce a final price
- The ability to update or alter any of the input data and to recalculate the estimate
- Proper reporting facility facilities

2.7.5. Current cost estimating Practices

As history proves construction to be a risky business, therefore it has been a usual practice by construction contractors to use a specific and established techniques for costing there work quantities. But in there research *Hegazy T. and Moselhi.O* (1995) have seriously argued that often in process contractors tends incline towards there self designed estimating techniques, which time and again proves to be inaccurate and unstructured and are based solely on contractors, own experiences.

It has been noticed in the current research and also in few other latest researches, that there is serious absence of literature on current construction cost estimating practices.

2.7.5.1 Summary of cost estimating practice

According to *Uman* (1991) it is difficult to make a standard process from which to develop an efficient cost estimating system for construction, this is due to factors including extreme diversity in building systems, methods, projects, suppliers, construction contractors and workforce accompanied with it. *Akintoye and Fitzgerald* (2000) had contended in there study with reference to *Bennett and Barnes* that ideal cost models cannot be developed as the actual costs of construction will depend on many factors, including contractors individual selection of construction resources and methods, and the timing and sequence of operations.

Based on the questionnaire survey, in there study *Hegazy & Moselhi* (1995) have produced a research report on the elements of cost estimating in Canada and the United States. There research also investigated relationships between mark-up and competition, need for work and contract duration, and stated various variations between contractor's estimates of different cost elements. There work also specify that direct cost and project overheads are estimated by contractors in a detailed manner, but not so in the case of general overhead costs and the mark-up, mostly due to the high level of uncertainty and lack of adequate decision support tools. Finally the research recommended the need for a set of estimating standards to be established and that, more effective decision-support tools for estimating purposes to be developed.

In his extensive research *Law* (1994) documented a systematic procedure, format and different methods involved in UK building contractor estimating in relation to labour, plant, material, subcontractors, overhead and profit. *Akintoye and Fitzgerald* (2000) illustrated in there study about the techniques or modelling tools for cost estimating which

can be classified in to four sets, namely Experienced based (algorithms, heuristics, expert system programming); simulation (heuristics, expert models, decision rules); parametric (regression, Bayesian, statistical models, decision rules); and discrete state (linear programming, classical optimization, network, PERT, CPM).

Shash and Al-Khaldi (1992) have described the importance of using parametric cost estimating techniques namely simple arithmetic formulae and statistical formulae. In there study *Akintoye and Fitzgerald* (2000) further illustrated the applications of cost factor estimation and capital cost estimation. This techniques of capital cost estimation, based on correlation techniques, uses a combination of material, labour and plant cost factors to produce an initial cost for a manufacturing unit. They further promoted the use of an assembly pricing technique (also known as work module pricing, system pricing, rapid pricing or aggregate pricing) referring to Bryan (1991). The assembly pricing method presents costs in composite pieces that can be related easily to the drawings.

In there study on production of accurate construction cost estimates, **Shash and Al-Khaldi** (1992) have identified factors affecting the accuracy of cost estimates, namely financial issues, bidding situations, project characteristics and the estimating process itself. The main factors identified in there study, irrespective of the size of contractors, was previous experience of the contractor based on the type of the project. The other factors namely anticipated or frequent delays in periodic payments, type and size of contract and project location followed the ranking respectively.

Based on *Beeston's* (1983) study, *Akintoye and Fitzgerald* (2000) has proposed a very simple method to improve estimating performance involving the use of several

methods for each estimate and maintaining records which will give the contractor an option to select the best and appropriate method or combination of methods.

2.7.5.2 Details of various cost estimating practices

Cost estimating practices of UK contractors, based on research of Akintoye and Fitzgerald (2000) and other researches:-

Uses of cost estimating:

In there study *Akintoye and Fitzgerald* (2000) identified the list of possible prominent uses of cost estimation based on literature review, namely:

1.To prepare tender for client
2.To control or monitor project execution
3.To audit project success
4.To staff project
5.To schedule projects
6.To select projects to tender for
7.To evaluate project estimator
8.To evaluate client

Based on the responses of 84 U.K contractors firms of various sizes, it was noticed that cost estimating is used more for project control and planning rather than for evaluation, this view holds good independent of size of the contracting firm.

But from the literature review and experience of peers in the construction, it is noted that cost estimation gets more accurate if it is aimed mostly for evaluation.

Techniques of cost estimating:

Based on the responses of 84 U.K contractors firms of various sizes, it was noticed that among the various cost estimating techniques, the three main cost estimating techniques opted by the contractors were:

1. Estimating standard procedure.
2. Comparison with similar projects based on documented facts.
3. Comparison with similar projects based on personal experience.

The other cost estimating techniques used by the contacting firms include:

Established Standards

4. Intuition
5. A simple arithmetic formula
6. Usage of software for estimating
7. Published Price information
8. Capital estimating factors
9. Shared information with subsidiary of the firm
10. Range estimating (based on probabilistic technique)
11. Guessing
12. Shared information from other construction firms
13. A complex statistical formula

Based on literature review and according to the peers in industry, main method being used by most of the firms is the “standard estimating procedure” which is found in most

estimating textbooks, where cost of construction (labour, material, plant, subcontractors) are established and to which an allowance for overheads and profit is added.

Causes of inaccurate cost estimates:

In the Research by *Akintoye and Fitzgerald* (2000), 84 U.K contractors firms of various sizes, were questioned about the most important factors for inaccurate cost estimates, based on 20 various factors obtained from literature review.

The research revealed that among the important factors, the insufficient time for cost estimating, followed by poor tender documentation and insufficient tender document analysis by the estimating team were absorbed to be the major causes. It is observed that generally these factors were rated more highly by small contractors compared with large contractors.

1. Insufficient time for estimating
2. Poor tender documents
3. Insufficient tender document analysis
4. Lack of understanding of project requirements
5. Poor communication between project team
6. Low participation in estimating by site team
7. Lack of review of cost estimate by management
8. Poor comprehension of site requirements
9. Poor feedback on accuracy previous estimates
10. Pressure from management
11. Removal of estimate padding by management
12. Poor project cost feedback
13. Lack of diligence by estimators
14. Lack of adequate guidelines for estimating
15. Inaccurate production data used in estimating
16. Lack of historical data on past estimates

17. Poor analysis of cost data for cost estimate
18. Lack of performance reviews of estimators
19. Estimators lacks of data processing techniques
20. Frequent requests for changing of estimate

It is observed from study, large contractors rated the causes of inaccurate cost estimates lower than the causes of inaccurate cost estimates lower than other groups. This indicates that the large contractors do not have much problem with cost estimating functions, probably because the cost estimating department of large contractors tends to be well organized with clearly defined tasks. Along with this, most large contractors use cost estimating software which addresses any problems of insufficient time for estimating, poor tender documents and all.

Cost estimating practices:

Based on the study of *Akintoye and Fitzgerald* (2000), conducted on 84 U.K contractors firms of various sizes, it has been observed that most participating contractors prepare detailed cost estimates for both small and large projects, but they have more inclination to prepare detailed cost estimates for large projects compared with small projects. This is justified, given that large projects tend to constitute a large proportion of most contractors' workload.

The study also revealed that following management personnel's are responsible for approving cost estimate for large projects:

1. Managing director
2. Estimating director
3. Chief estimator
4. Technical director
5. Others; commercial director

Following management are responsible for approving cost estimate for small projects:

1. Chief estimator
2. Managing director
3. Estimating director
4. Technical director
5. Others; commercial director

Following are the participants in the cost estimating process, in the order of there rank:

1. Estimators
2. Subcontractors
3. Managing director
4. Contract managers
5. Quantity surveyors
6. Site management
7. Store managers/buyers
8. Others; planners

2.7.6. Relation with Other Departments

The Boundaries and barriers which are built up between departments, functions and shifts are barrier to teamwork and inter-departmental working and co-operation. An efficient contractor organization will have an efficient interaction between its various departments for accomplishing the project with better quality in prescribed time and cost.

A cost estimate developed by the estimating department is the responsibility of entire project team, the estimators alone doesn't assume the responsibility for its accuracy (Dysert et. al, 2000). Developing a competitive estimate requires a close links with project management and project controls personnel. After the preliminary estimate is developed, it is important that adequate change management is in place so that changes in project scope can be assessed, and the project estimate is updated accordingly (Dysert et. al, 2000)

Cost estimators generally work alongside with project controls department to format estimates so that they can be cast in the project work breakdown structure, and to assist in preparing schedules and resource plans (Dysert et. al, 2000).

The need for links between planning & scheduling and cost engineering cannot be under emphasized, the combined efforts of the cost engineering and planning functions can be explained as a set of actions to establish and maintain rigorous technical quantities, cost control, and time planning at the earliest stage of and continuously through a project, so that acceptable compromises between costs, program and performance can be authorized, thus ensuring that objectives are met (*Beguinot & Robinson*, 1992).

2.7.7. Recommended Traits & Practices of Ideal Contractor

Based on the extensive literature study, following construction Cost Estimating related organizational aspects & practices are recommended for the benchmark contractor.

Traits:

I) Function: The key functions of the contractor Cost estimating department are:

- Forecast the Direct and indirect costs of the projects.
- Generate Quantity takeoff.
- To prepare tender for client.
- To control or monitor project execution.
- To schedule projects.
- To audit project success.
- To evaluate project estimator.
- To select projects to tender for.

II) Best Location in the Organization: - Reporting directly to the Vice president of the organization, who in turn will coordinate with the Chief Executive or top management.

III) Key Players in Cost Estimating Department: -

- Chief Estimator
- Construction Manager
- Estimating Staff
- Quantity Surveyors

IV) Characteristics of Cost Estimators:-

An efficient cost estimator is expected to have the following traits

- Comprehensive general Skills
 - Mathematical skills
 - Up-to-date knowledge of latest construction trends.
 - Knowledge of Cost details, etc.
- Communication Skills
- Software Skills
- Business Skills

V) IT Technology employed (Estimating Tools): - The Cost Estimating departments should employ software's like:

- Timberline Software
- SoftCOST
- WinEstimator
- CONAC Group
- ArchiCAD; etc.

VI) Relation with Other Departments: - Contractor safety department will have good contacts and also directly affects its safety practices on *Cost Estimating, Planning & Scheduling, and Quality Departments.*

Safety department shares a close interaction with the planning & scheduling counterparts. A safety results depend to a large extent on project schedules and schedule updating.

VII) Company Estimating Manual/Program: - The contractor should have his own Estimating manual, which shall speak about:

- Overview of the estimating process;
- Review of estimate requirements;
- Planning the estimate;
- Structuring the estimate;
- Developing the estimate;
- Documenting the basis of an estimate;
- Estimate reporting; etc.

Cost Estimating: Best Practices:

1. Construction Cost Estimation shall be performed prior to the bidding stage.
2. A contractor with a multiple number of estimators and division should establish department estimating procedures, illustrating guidelines for preparing estimates, in an “estimating manual”.

3. Extensive training should be conducted for each estimator; training for each individual estimator is expected to be summarized in a document called the “Employee development plan”.
4. Estimating tools must be kept up-to-date for maximum effectiveness.
5. For an estimating department, training of estimating professional is equally or more essential than the selection of estimating professional.
6. Proficient contractor shall have effective communication with project management and project controls department.

2.8. Planning & Scheduling Department

2.8.1. Introduction

The expertise to manage and control a project is of greatest importance for its successful accomplishment. Planning and scheduling are vital for the successful completion of any project, and provide a way to achieve and sustain schedule control.

Planning, Scheduling are one of the most important construction management concepts. Planning involves gathering information about the five planning resources, materials, machines, manpower, money, and time. The first four resources should be matched with time in order to maintain a reasonable work schedule meeting the milestones of a project. (*Ubaid 1991*)

He further determined that planning and scheduling rank number two in his fourteen measures affecting the performance of contractors. The importance index is 90% on contractor performance.

The successes or failure of a contractor firm by in large depends on there planning and scheduling department, hence the importance of the various planning and scheduling techniques to their firm's can never be overshadowed.

According to *Ali Shash and Abdullatif* (1993) the majority of contractors, regardless of there firm size, consider the planning and scheduling techniques very important to their firm's current success.

Subaie (1987) found that planning and scheduling mistakes can be a reason for claim. He determined that the importance index is 64% in causing claim.

2.8.1.1 Desired outputs of Planning and scheduling

Project planning and scheduling is the core of any successful project management, because it grants the innermost communication that coordinates the work of all parties. Planning and scheduling also establishes the benchmark for the project control system to track the quantity, cost, and timing of work required to successfully accomplish the project (*Oberlender G*; 2000).

It is noted that planning is usually the first step to project scheduling, as the changes takes place, additional planning is required to incorporate the changes into the schedule. Good planning detects the changes and amends the schedule in the best efficient way.

Key Aims of Project Planning and Scheduling:-

1. To finish the project on time.
2. Continuous and unremitting flow of work without delays.
3. Reducing the volume of rework.
4. Limiting the confusions and misapprehension.
5. Up to date knowledge of proceedings of the project by all members.
6. Meaningful and timely reports to management.
7. Clear comprehension of who does what, when and how much.
8. Integration of entire work to make sure a quality project for the owner.

9. Authorities run the project instead of being run by the project itself.
10. Acquaintance of the scheduled times of key parts of the project.
11. Knowledge of division of costs of the project.
12. Accountability of the individuals, their responsibilities and powers.

Project planning and scheduling can serve as an effective means of preventing loads of problems. The proper execution of this technique can prevent delays in work, a major reason of late project completion and cost overrun, which more than often leads to disputes. This will subsequently prevent low worker morale and decline in productivity which is result of wayward direction.

2.8.1.2 Axioms of Planning and Scheduling

In the same way as every department, planning and scheduling section usually must have an explicit operational plan to guide the project. The plan must include and effectively link the three components of the project namely scope, budget and the schedule. Usually it will be seen that planning focuses mostly on scheduling without regard to the important components of scope and budget.

In his book, *Oberlender G* (2000), mentioned that project plan and schedule must clearly define individual responsibilities, schedule, budgets, and anticipated problems.

Planning, scheduling, and controlling begin at the inception of the project and are continuous throughout the life of the project until finishing point. Following are the key principles for planning and scheduling.

1. Begin planning before starting work, rather than after starting work.
2. Involve individuals who will actually do the work in the planning and scheduling process.
3. Include all aspects of the project, including scope, budget, schedule, and quality.
4. Build flexibility into the plan, include allowance for changes and time for reviews and approvals.
5. Remember the schedule is the plan for doing the work, and it will never be precisely correct.
6. Keep the plan simple; eliminate irrelevant details that prevent the plan form being readable.
7. Communicate the plan to all parties; any plan is worthless unless it is known.

2.8.1.3 Position of Planning and Scheduling Function in an Organization

In an efficiently working contractor office, the Planning and scheduling department along with other specialists, including engineers, purchasing agents, and construction managers will be headed by a single individual called the project manager, who in turn will be preceded by Chief Executive (*Alcabes*, AACE 1988). Under the project manager

various specialists will be assigned the responsibilities of performing the work within their sphere, while it is the responsibility of the project manager to coordinate these activities so that the overall objectives can be met within a required schedule and required budget.

Planning and scheduling activities of a construction operation must be initiated when the prebid estimate is being prepared. It involves the development of a concept for performing the various items of work necessary to execute the contract efficiently and on time. From a practical viewpoint, planning is a perpetual part of estimating since an unpriced plan is an unknown quantity (*AACE*, 1990).

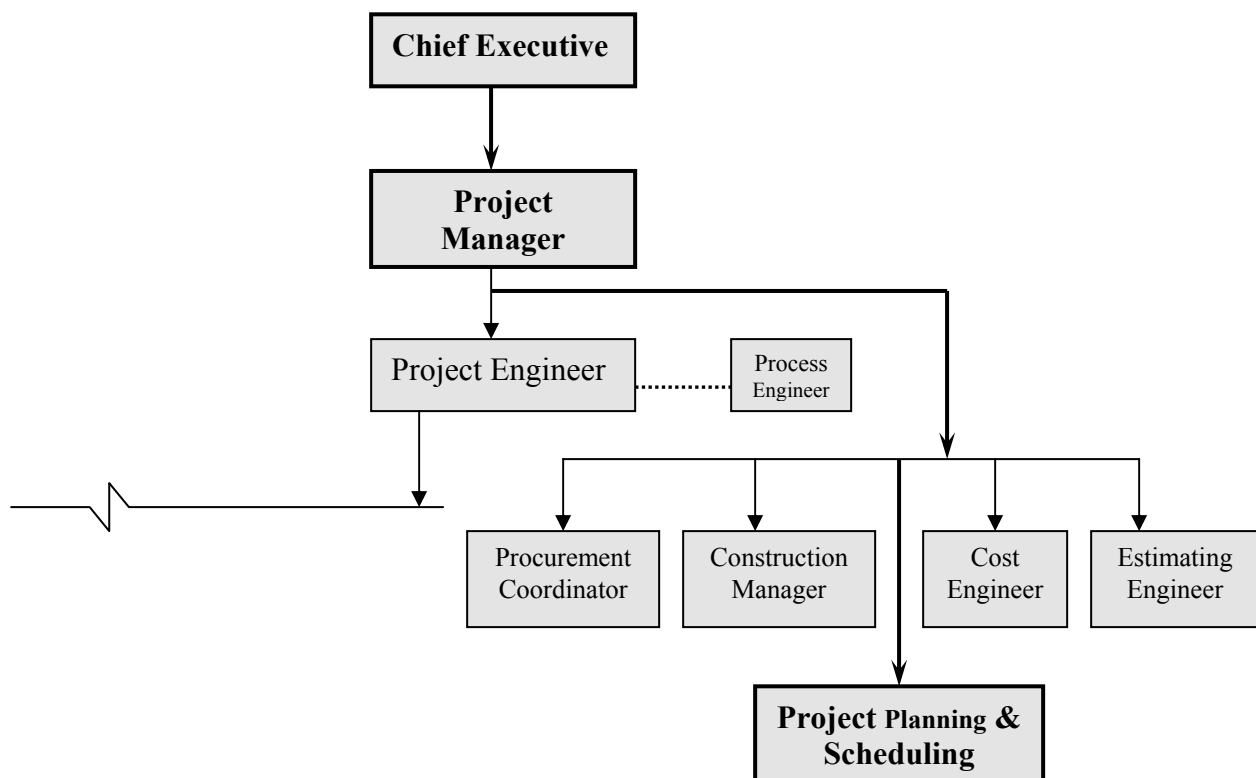


Figure 2.8: Example management organization showing the suggested position of Planning & Scheduling department

2.8.2. Organization of Planning & Scheduling Department

Planning and Scheduling department is one of the most prominent functions for the successful working of the contractor firm.

In a contractor office, the planning and scheduling department will be under the proficient supervision of the chief engineer. This department will be responsible for developing detailed project planning, project schedules, monthly progress reports, and network diagrams based on information generated by the various other departments in the organization (*Alcabes, 1988*).

With respect to the work in progress, the contractor's engineering staff, under the proficient direction and the cooperation of the project management, should prepare detailed programs for performance of the work. Sometimes the contract conditions establish the form, the method, and the detail required for project programming. The contractor must, in his own interest, and whether or not it is provided for in the contract, maintain comprehensive project planning throughout the work. Such planning and scheduling is the primary basis for control, efficiency, and good management of the operations. These functions will decide the contractors overall success or breakdown.

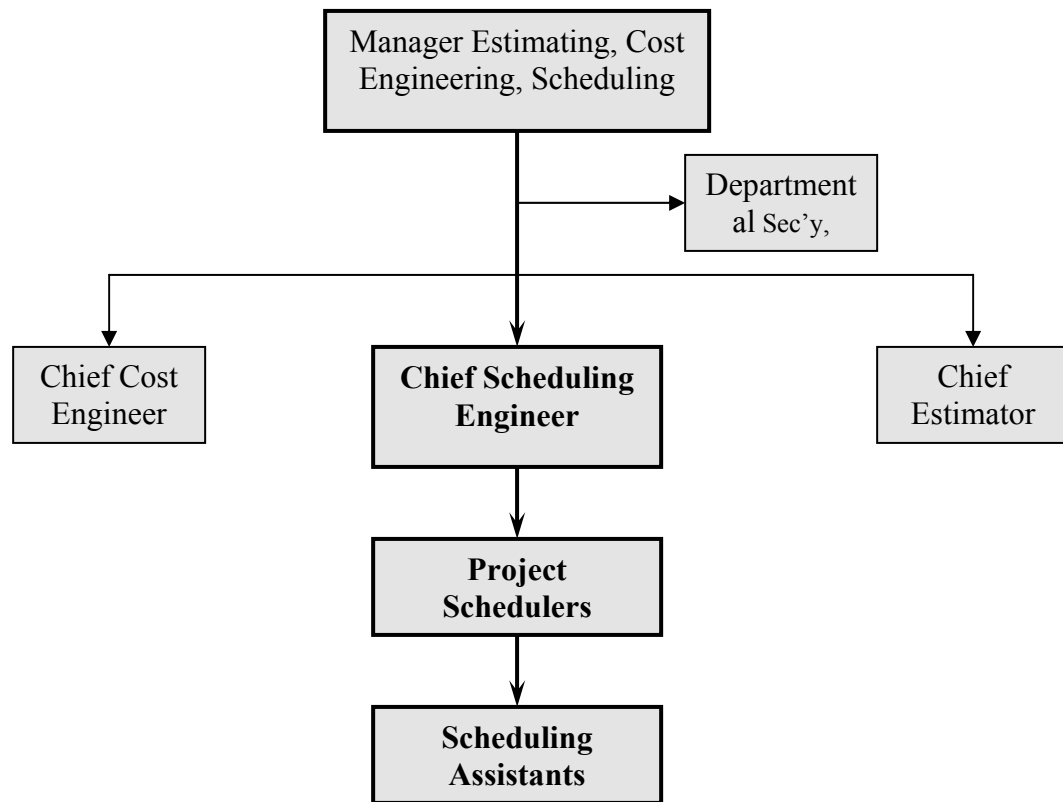


Figure 2.9: Example showing the suggested Organization of Planning & Scheduling department (Developed from *Alcabes Joseph*, AACE, 1988)

2.8.2.1 Planning and Scheduling Department

Objectives:

The aim of planning function within a management team is to review job requirements and review of responsibilities so that an acceptable course of action may be determined to perform a project in an optimum manner (*AACE, 1990*).

The aim of scheduling function with in a management team is to implement the agreed upon project plan and monitor progress towards the desired results (*AACE, 1990*).

Among the various responsibilities of planning and scheduling departments, the prime objectives will be to insure that the supervisors, the project manager and the manager of operations are made aware of all conditions, particularly those in the home office are lacking behind or probably to delay the progress of a project. In addition, the chief planning and scheduling engineer will work in alongside with the proposal manager in the preparation of the project schedules for use in proposals that are to be submitted to would-be clients (*Alacabes, AACE, 1988*).

2.8.2.2 Principles of Effective functioning Project Planning

For the efficient functioning of project planning personnel in achieving there objective, *AACE, 1990*, planning and scheduling committee suggested the under listed requirements:

- A. Establishing a scheduling development procedure to determine scope of work, client dictated parameters, schedule hierarchy, division of project responsibility, schedule approval and requirements and distribution.
- B. Recognizing major activities to be performed and the preferred sequence in which they are to be accomplished.
- C. Setting up an integrated plan to achieve completion as required.
- D. Coordinating with project management to establish cost/schedule areas for the further definition of the scope of work

2.8.2.3 Principles of Effective functioning of Project Scheduling

For the efficient functioning of project scheduling personnel in achieving their objective, *Alacabes, 1988* suggested the under listed principles in an aace conference:

- A. Follow the equipment and material schedule persistently, anticipate delays, weigh the consequences of missed dates, point out actual or potential problems to management and assist in resolving difficulties, insert actual dates on the report, and issue it as needed.
- B. Work compactly with the project manager. Advocate him immediately when problems are not being resolved by the line, or when he is behind schedule in meeting his duties. Assist him in his efforts to provide coordination, communication, and liaison among the specialists assigned to his project.
- C. Establish the equipment and material schedule:
 - 1. To begin with, make sure that each part of equipment and commodity items are scheduled from engineering through procurement and delivery at the job site.
 - 2. Issue the equipment and material schedule as required.
- D. Evaluate all schedule dates including vendor drawing requirements, client approvals, drawing releases, field delays and all other matters affecting scheduled performance.
- E. The Scheduling department should develop logic diagrams from available information which shall be reviewed and approved by management.

- F. All schedules shall be in accord with the classification of accounts system established for the project so that costs and schedules can be readily related.
- G. The scheduling department's accomplishments will be gauged against:
 1. The accuracy, promptness, clarity and usefulness of the records and reports produced.
 2. The quality of assistance provided to the project manager and other departments.
 3. The ability to anticipate difficulties, identify their implications and issue a timely call for review and remedial action.

2.8.2.4 Planning and Scheduling Engineer

The key purpose of the planning and scheduling engineer in the department is to assist the project management team in developing, monitoring and updating an integrated project plan so that the project may be executed in the most efficient manner possible.

Duties of planning and scheduling engineer:

Planning and scheduling engineer is one of the key for effective working of the department, he is accepted to accomplish the following duties:

General Duties:

Establish and maintain a high level of technical expertise through continuing education programs and participation in cost/schedule related professional activities.

- Assist in the development and implementation of improved planning and scheduling techniques and methods.
- Prepare project planning and scheduling related procedures and guidelines.
- Furnish planning and scheduling technical guidance and training to project personnel.
- Facilitate in developing and recording historical scheduling information for use on later projects

Specific Duties:

- Interface with, and obtain input from, project personnel for the development of project plans and schedules that reflect the defined scope of work.
- Develop quantity and labor expenditure rates for all project activities.

Progress Monitoring:

- Update schedules on a recurring basis assess the actual progress against the preplanned progress.
- Review impact of critical path and near-critical activities and account critical work activities to the project manager. A critical work activity is defined in numerous ways as under:
 - a. It is an activity which is not meeting the expected rate of production such that the project objectives will be accomplished on or ahead of the scheduled.

- b. An activity that indicated a required resource allocation which is either unattainable or unmanageable.
 - c. It is an activity whose late completion will delay the timely achievement of project objectives.
- Supervise schedule deviations and assist in developing alternative methods for corrective action.
 - Carry out value analysis upon recommended alternatives to determine cost/benefit tradeoff and present recommendations to project management.
 - Revise schedule as directed by the project management and ensure that schedule changes are communicated to all project team members.

Management Coordination:

- Present and respond queries on project plans and schedules at project meetings.
- Perform analysis to evaluate alternate plans, work-around courses of action or otherwise amend, plan, schedule and forecast as advised by project management.
- Work in concert with project cost engineers, quantity surveyors, estimators and material control personnel to ensure cost and schedule integration.

2.8.3. Information Technology in Planning and Scheduling

Information technology is playing an ever-increasing role in the delivery of projects. Computer programs are associated in just about every aspect of project work, from the discovery of a problem or an opportunity to the commissioning and start-up of a completed facility.

The planning and scheduling processes form the basis of project management today. Most construction firms use formal scheduling procedures whenever the complexity of work tasks is high and the co-ordination of a multiplicity of different operatives and trades are required (*Retik A, Langford D*, 2001). But sometimes the enormity of the project would render efficient project planning and scheduling unfeasible if it were not for the computerization of the planning and scheduling duties.

In the research conducted by *Ali Shash and Abdullatif* (1993), constituting 200 construction contractors, on query to assess the factors that were responsible for the assessed degree of success, the majority of contractors, regardless of their size, indicated Use of “good Computer programs” as the second main factor. Further, Factors of failure includes poor computer programs, lack of specialists using the planning and scheduling technique and the use computer programs that are very complicated.

In a survey conducted by *Contractors business management report*; 2002, regarding the use of technology as a means to increase efficiency, there were encourage results from general contractors about the same. The survey further revealed that, 41% of

the contractors surveyed, were currently using the Project planning and scheduling software's and further 59% were planning to use the same in coming six months.

Suhanic (1998) articulated that every rising project management techniques have generated a great deal of project management software to run methods such as the project evaluation and review technique (PERT) and critical path method (CPM). One such recent system is AutoPROJECT, based on AutoCAD.

Suhanic (1998) further articulated that CPM, Invented for process plant turnarounds, was initially aimed at improving construction labor productivity. Eventually, other aspects, such as procurement and management decisions, were included in the CPM planning net-works and schedules. Today, there are many CPM-based computer tools for scheduling and project management.

Other popular project management software packages include Primavera Project Planner for Windows, CA-SuperProject for Microsoft Windows, and Microsoft Project

With the growing, rapid advance in computer use, the use of software packages has improved rapidly in recent years. There are large array of Planning and scheduling packages, primary among them are including:

• Primavera Project Planner P3
• Microsoft Project
• Primavera Suretrak
• Project Scheduler
• AutoPROJECT

<ul style="list-style-type: none"> • CA-SuperProject
<ul style="list-style-type: none"> • Others;

In his research about CPM networks, *Street Ian*, (2000); adduced that with the advent of the windows operating system, scheduling software has become increasingly user friendly. He further mentioned that CPM software has attained a level of sophistication at which it is now practical to accurately depict all phases of a project, right from the design development through completion with wide-ranging details.

Primavera project Planner (P3), planning and scheduling software applications are considered the industry heavyweights. It gives today's project managers and schedulers the one thing they value most, control. It's a clear choice of project professionals in the engineering, construction, architecture, utilities, and telecommunications industries for controlling large and complex projects. P3 is designed to handle large-scale, highly sophisticated and multifaceted projects. To organize projects up to 100,000 activities, P3 provides unlimited resources and an unlimited number of target plans (www.primavera.com).

Microsoft Project, 2002 is and project management tool, very effective for planning and scheduling of construction activities. The software provides organizations with an extensible technology platform to securely develop and successfully deploy best practices for project management across the organization. Microsoft Project has effective web access facility, which enables entire project teams including team members, resource managers, and executives to stay informed, up-to-date, and on track

(www.microsoft.com). These features make Microsoft project ideal planning scheduling software for contractors.

Primavera SureTrak is effective for projects with total activities less than 500, to create both critical path networks and Gantt charts. In primavera suretrak Projects plans and specifications are reviewed to determine which activities to include in the networks. When all the information has been collected and incorporated into the network schedule, a planned schedule is issued.

CA-SuperProject is a project management software specifically designed and compatible for Microsoft Windows.

AutoPROJECT which is based on AutoCAD is an project management software to run methods such as the project evaluation and review technique (PERT) and critical path method (CPM).

Disadvantages:

It is expected that with further advances in scheduling software, the cost of delay analysis should have diminished. Further, the effectiveness/reliability of analyses should have increased dramatically. But according to *Wickwire & Ockman* (2000); unfortunately, use of inexperienced personnel to schedule the work, as well as supposed user-friendly software advances have led to very serious scheduling abuses.

Wickwire & Ockman (2000); further mentioned that the field of construction scheduling today presents a landscape with too many draw backs and disadvantages.

While the majority of schedules in use today present excellent tools for planning and scheduling projects, but too many of today's schedules fall into the flawed category.

According to *Suhanic* (1998) one possible negative aspect of the introduction of computers in the field of construction planning and scheduling may be the apparent degradation of the CPM/PERT network planning procedure in favor of the easy to use, graphical user interface produced bar chart. There always an uncertainty whether these screen produced bar charts are as effective as logic diagrams

2.8.4. Current Practices

Planning and scheduling should be performed according to the kind of organization and project a construction firm has at hand. Selecting the, ideal planning and scheduling environment for any business may give a contractor the competitive edge he is looking for, over his counter parts.

One of the key concerns for contractor in choosing a planning and scheduling working package is smoothness. It must be kept in mind that for a planning and scheduling to work, it must be easily and clearly understood by all the team (*Manzanera*, 1990). A confusing system will not be comprehended by all, resulting inaccurate results.

Over the past few decades numerous planning and scheduling techniques have been developed and being brought into use by the construction contractors around the world. Based on several researches about the most widely used & currently employed planning and scheduling practices, Critical path method (CPM), Program evaluation and review

technique (PERT), graphical evaluation and review technique (GERT), and Gantt bar chart (GBC) are few, renowned among contractors.

2.8.4.1 Critical Path Method

The Critical path method is a technique developed particularly for the time management of construction projects. This technique provides information necessary for the time scheduling of a construction project, escort the contractor in selecting the best way to minimize project duration, predict future manpower and equipment requirements (*Clough & Sears, 1994*). According to *McCullough* (1999), Critical path method of scheduling has gained prominence in the construction industry as the method of choice for scheduling projects of virtually all sizes. He further articulates that CPM scheduling is also recognized as the one of most precise tool for performing an analysis of delays to a project. The CPM network can be used as the basis for monitoring project progress. *Loulakis, Cregger* (1993) adduced that CPM schedules are valuable tools to assist a contractor in planning and performing a construction project. They may also be an invaluable aid in documenting and proving construction delays and disruptions.

Clough & Sears, 1994; adduce that CPM is widely used procedure for construction time control, and contractors are now frequently required by contract to apply network methods to the planning and scheduling of their work. The CPM network can be used as the basis for monitoring project progress.

However, along with the numerous benefits associated with CPM, there are few pitfalls linked to this widely used technique. In his comprehensive study on pitfalls of

CPM scheduling on construction projects, *Street Ian*, 2000; indicated five major pitfalls affiliated to CPM. To begin with, the Critical path may not always require the most attention, because an activity critical today might not be critical the next day. The critical path identified in the original scheduling iteration only remains on the critical path if everything goes according to plan. Secondly, the CPM network's characteristic of going for unrealistic activity durations. All too often, the duration of activities in a network are wild guesses that may be unrealistically short, and were calculated by how much time is available to complete the project rather than how long the activity actually takes to complete.

The third Pitfall articulated by *Street Ian*, 2000; is that in CPM technique, The owners does not manage the schedule. A successful contractor realizes that he is most efficient when the project schedule drives the work, but an inefficient contractor will take things easy, without the intervention of the owner. Most contractors, however, do not have in-house CPM expertise and the result, although well intentioned, will be a poorly developed and poorly maintained schedule, without the involvement of the owner. The forth pitfall cited is accepting CPM schedule reports without the electronic file. CPM is a method in which all activities within a project are feed into scheduling software, and each activity is linked by schedule logic, resulting in a reasonable plan for accomplishing the work. With improper schedule logic, the schedule becomes useless, and in some cases, misleading to the point where you don't recognize the danger until its too late. Lastly the poor maintenance of CPM schedule, that is failure to perform timely schedule updates.

Advantages:

- Identifies the activities that control the project length.
- Determines shortest time for completion of activities.
- Identifies the activities that are critical, that cannot be delayed.
- Shows available float for non-critical activities.
- Allows monitoring & control of fast-track projects.
- With software can be resource loaded and leveled.

Disadvantages:

- Only as good as effort put forth to properly model the plan.
- Can be difficult to properly update.
- Can be easily misused.
- May lead to false sense of security.
- Actual conditions may necessitate significance modifications to model to accurately reflect reality.

2.8.4.2 Project Evaluation and review technique

Project Evaluation and review technique (PERT) is an project management technique for determining how much time a project needs before it is completed. Each activity is assigned a best, worst, and most probable completion time estimate. This estimates is used to determine the average completion time. The average times are used to

figure the critical path and the standard deviation of completion times for the entire project.

The PERT technique considers a project to be an acyclic network of events and activities. The time duration of a project is established by a system flow plan in which the duration of each task has an expected value and a variance (*Cottrell Wayne D*, 1999). Further the PERT can be used to estimate the probability of completing either a project or individual activities by any specified time. With is technique it is also feasible to establish the time duration corresponding to a given probability. *Ali Shash and Abdullatif* (1993) adduced that PERT was developed with the objective of being able to manage uncertainties in activities completion times. It is a combination of network and probability theories.

But along with the various applications, conventional PERT technique is followed with few negative aspects. In his research *Cottrell Wayne D.* (1999) published that there are five recognized problems with PERT, firstly it is difficult for project engineers and planners to accurately estimate the optimistic, most likely and pessimistic durations of an activity. Secondly, the mean and variance of activity duration are usually estimates of the actual mean and variance of a beta distribution. Thirdly, the beta distribution is presumed to be applicable to all project activities. Fourthly, PERT considers only the critical path in computing project completion time probabilities. The method clearly ignores near-critical paths that posses a near significant likelihood of becoming critical. Lastly, the one of the primary shortcoming of PERT in construction applications is that it requires multiple time estimates, which can be time-consuming to build up.

2.8.4.3 Precedence Network Diagram

Precedence network diagram is an activity oriented system in which activities are displayed in uniform boxes complete with activity number, start duration and finish dates. The logical relation between activity boxes is shown by logic connector lines. Lead and lag times can also be shown. The display is more effective than Arrow Diagramming and is also easier to revise, update, and program on computer. The Precedence network diagram similar to Critical path method, assume that the duration of an activity is deterministic.

Precedence network diagram have quite a few advantages, similar to CPM. Firstly the networks can much more concisely represent large numbers of activities. Secondly, one of the major aspects of a planner's thinking, that is, the logical interrelationships and dependencies among activities, which is not really shown on bar charts, are inherent in network diagram (*Barrie & Paulson*, 1984). This technique is also said to encourage a higher level of logical discipline in the planning, scheduling, and control functions, and to stimulate more attention to both long-range and detailed planning.

2.8.4.4 Gantt bar Chart

A Gantt chart is a time-phased graphic display of activity durations. It is also referred to as a bar chart. Activities are listed with other tabular information on the left side with time intervals over the bars. Activity durations are shown in the form of horizontal bars.

Ali Shash and Abdullatif (1993) adduced that Gantt bar chart is one of the oldest planning and scheduling methods. It is a graphical representation of project activities that are necessary to be executed to complete the project. They further mentioned that in Gantt bar chart technique, activities are represented by bars that are graphed against the start, duration and finish time of the corresponding activity.

The bar chart, as well as providing a plan for the project allows one to monitor progress by drawing on the bar chart the completion or progress of each activity. As it is on a time scale one may indicate the date now by a vertical line hence highlighting any variance for which action is required.

The main advantages of the bar chart are:

- its simplicity;
- its use for recording progress and so controlling the works;
- ease of amendment;
- use in scheduling resources (resource aggregation chart);
- easily understood by sub contractors;
- Parts can be abstracted for different trades or color coded.

The main disadvantages are:

- Planning and Scheduling are considered simultaneously.
- Activity dependencies cannot accurately be shown.
- Difficult to determine how activity progress delays affect project duration.

- Difficult to establish and maintain for large projects.
- Simplicity precludes sufficient details for timely detection of slippages.

2.8.4.5 Graphical Evaluation and Review Technique ("GERT")

Graphical evaluation and review technique, is a network analysis technique that allows for conditional and probabilistic treatment of logical relationships (i.e., some activities may not be performed).

According to *Ali Shash and Abdullatif* (1993), GERT is a combination of network theory, probability theory, and simulation technique. GERT determines the probability of the realization of a node in a network based on statistical data that are collected through simulation.

2.8.4.6 Planning Scheduling Practices in Saudi Arabia

Saudi Arabia, one of the biggest recipients of construction services, had its boom in 70's and 80's. The subsequent decline in construction activities and economic factors prompted the competitive construction industry to opt for more ingenious and conservative construction techniques. These changes in construction environment directed both the government and accordingly the contractors to search for more competitive practice. These competitive practices include rapid innovation in the contractors department of planning and scheduling.

In there extensive and discrete researches, over 200 and 120 construction contractors, respectively in Saudi Arabia, *Ali Shash and Abdullatif* (1993) & *Al-Hammad and Dr. Assaf* (1988) articulated that, Critical path Method (CPM), Program evaluation and review technique (PERT), precedence network diagram (PND), graphical evaluation and review technique (GERT), and Gantt bar chat (GBC) are some of the techniques recognized and employed by those contractors.

Al-hammad and Dr. Assaf (1988) further expressed that there are large percentage of firms utilizing CPM, PERT and PN techniques, they indicated that improved planning before works commencement is a major benefit for them. In addition, definite cost savings and improved project control after work initiation are also part of these practices.

In terms of acquaintance with the various planning and scheduling techniques available, it is noticed that almost all the contractors are familiar with CPM, around 91 percent are well-known with the GBC technique, and about 53 percent, particularly large contractor are familiar with PERT technique. Where as GERT and PND technique are hardly known to Saudi contractors (*Ali Shash, Abudllatif* ,1993).

It has been absorbed that bulk of the Saudi contractors are inclined towards employing CPM, GBC and Pert techniques for efficient planning and scheduling and as a cost reduction technique (*Al-Hammad...el.*)

According to *Shash & Abdullatif* (1993), regarding planning and scheduling technique exercised based on the different job sizes. Evidently GBC is the most widely used technique for almost all the job sizes, while CPM is used widely for jobs that are

greater or equal to SR 5 million. Similarly it was also noticed that CPM and GBC techniques are most predominantly used techniques for any project duration.

The exploratory research of *Ali Shash and Abdullatif* (1993) & *Al-Hammad and Dr. Assaf* (1988) also revealed that CPM, GBC, PERT and PN are largely employed at detailed planning stages prior to construction. CPM and PERT are utilized mainly at the project management level, while PN and GBC are used at the division management level. The main benefits derived from these techniques are proficient planning at preconstruction stage, then definite cost saving and improved project control as the work progresses.

2.8.4.7 CPM Preferred Scheduling Technique

Planning and Scheduling department of contractor have tried various techniques over the decades to program their work and also to prove delays. These include Gantt charts and partial or truncated CPM schedules. These methods have met with very limited success, the major amount of cases indicate a preference for CPM analysis (*McCullough*, 1999).

Further it has been widely noticed that the current construction contracts are becoming more complicated and demanding in their requirements for contractor-developed and maintained CPM schedules. Also the owners are demanding CPM schedule impact analysis on all change orders and time extension requests as a testimony that the contractor they hired is entitled to a time extension and associated cost factors (*McCullough*, 1999).

This major inclination for CPM analysis is defended by the clever concept of a critical path that can more clearly depict the cause-and-effect relationship between impacts and delays to the project. From contractors view point CPM is the most recognized system in courts for obtaining construction claims, in addition it is most established and preferred schedule management tool for construction.

Ponce de Leon, Gui (1991) expressed that CPM is undoubtedly the method of choice for managing schedules on construction contracts. Except in some isolated cases, where CPM may not have reached a contractor, owner A/E organization.

2.8.4.8 Size of the firm and Technique Employed

For the efficient and successful accomplishment of work, contractors are expected to have a proficient planning and scheduling department and a simultaneously utilize some good planning scheduling technique, irrespective of the size of the contractor firm.

In there research concerning 200 contractors, *Ali Shash and Abdullatif* (1993) articulated that majority of contractors, regardless of their size, enumerate that Planning and scheduling techniques as very important for there firm's successes. But they are used mainly at the project management level. The subsequent uses of these methods, among small-sized contractors, are at the division and group manager level and at the bidding and/or estimating level. Unpredictably very small number of contractors used these techniques at the superintendent level, where they are more productive, and are expected to be utilized.

The extensive research of *Ali Shash and Abdullatif* (1993) reveals that CPM and GBC technique are employed by all the contractors irrespective of their size. The other techniques of PERT and PND are famous among the Large and Medium size contractors, the small contractors avoid using this technique. The majority of the large contractors consider PERT technique very important to their success, medium-size contractors consider it modestly important. Surprisingly although being familiar with GERT technique, most of the contractors evade using the same, irrespective of their size.

2.8.5. Documentation to Support Schedules

It is extremely important for the contractor to maintain proficient documentation and record-keeping, particularly in the area of daily reports. Also it is essential to maintain the details of the actual progress of the work, including the start and finish dates of each activity. In addition to this, a contractor should give an attention to include in daily reports, records of disruptions occurred to a particular activity and what caused those disruptions. It is always good to show in a report, when the disruptions occurred and what impact it had. Among the construction personnel the foreman knows how long the activity should take, he also knows what reasonable progress toward the goal should be made, and when progress is not made. But if the construction foremen is not much literate as expected, in that case a good project control system incorporates a daily report that identifies problems on a daily basis. These problems can then be investigated by personnel who could investigate and document the impact more fully (*McCullough*,1999).

2.8.6. Communication for Successes of Department

Sound process of sending and receiving information and messages within the department is essential to achieve understanding and consequently establish remarkable planning and scheduling system. This system constituting flow of information, within the department includes the diligent participation of top management and the personnel using the system, together with the every individual involved in the process.

In the research conducted by *Ali Shash and Abdullatif* (1993), constituting 200 construction contractors, to query to assess the factors that were responsible for the assessed degree of success, the majority of contractors, regardless of their size, indicated that top management involvement & support, good training of personnel and consistent support from personnel using the system are the prime reasons for the successful implementation and achievement of benefits of the planning and scheduling techniques. Subsequently the contractors alleged that lack of involvement from top management and insufficient support from personnel using the system are major cause of ineffective system.

2.8.7. Schedule Monitoring and Updating

Just as project planning and scheduling are necessary to ensure that a project is accurately and sensibly structured, it should also be equally necessary to properly monitor the project progress to ensure that all changes are incorporated into the original plan and that the completion date has not been put at risk.

Kursave, Jeffrey D. (2003) adduced that Project planning and scheduling is a necessity of proper management. Project updating is equally as important. Regular monitoring and updating progress is necessary in order to evaluate if the original plan was correct and if the project completion date is still good. Project updating also serves as a documented record of actual work progress.

According to *Baweja Satinder S.* (2003) a good update requires a method to gauge progress and an effective “modification” of the plan based on current conditions and knowledge. The frequency of an update will be based on the complexity, size, and nature of project. Updates range from daily to monthly, based on the abovementioned factors.

Baweja Satinder S. (2003) further mentioned that the project may require a combination of measurement methods to be used on the project based on the kind of work being measured. Among the most common methods to measure work progress are the following.

- Units of work completed
- Opinion
- Milestone achievement

In his research on “Relationship between planning and Safety” *Veteto* (1994) presented an exceptional application of schedule updating. He mentioned that frequent updating of project schedules allows all participants to foresee areas of possible conflict. The importance of frequent schedule is portrayed in table below. The best safety performances were on projects that frequently updated project schedules.

TABLE 2.1: Relationship of Frequency of Project Schedule Updating to General Contractor Injury Frequency

SCHEDULE UPDATED	INJURY FREQUENCY
Daily	42
Weekly	63
Twice	113
Monthly	91

2.8.8. Relation with Other departments

Studies have demonstrated that projects with good final outputs will be well organized and will have close interaction between its project management elements of Cost, schedule, safety and quality department.

Beguinet & Robinson, (1992) Stated, emphasizing the relation between planning and scheduling and cost engineering that, The combined efforts of the cost engineering and planning functions can be explained as a set of actions to establish and maintain rigorous technical quantities, cost control, and time planning at the earliest stage of and continuously through a project, so that acceptable compromises between costs, program and performance can be authorized, thus ensuring that objectives are met. He further mentioned that Cost engineering is inextricably linked to the planning function.

While the Independence of Planners, schedulers, cost engineers, construction individuals and estimators in many respects is an admirable trait and is sometimes absolutely essential in order to be successful at work, the skills and output of each of these individuals need to be integrated and directed toward a common goal if major construction projects are to be completed within budget and on schedule *Epstein George*, (1985).

Epstein George, (1985) further adduced that the Functions that are often not utilized effectively are: estimating, planning, scheduling and cost engineering. Yet, when integrated and make the most of by management, the combined contribution of these integrated functions by vital project team members adds immeasurably to effective project management. It also establishes a basis for communication among construction personnel and those responsible for project estimating, planning, scheduling and forecasting costs.

In his research on “Relationship between planning and Safety” *Veteto* (1994) presented an exceptional application of schedule updating. He mentioned that frequent updating of project schedules allows all participants to foresee areas of possible conflict. The importance of frequent schedule is portrayed in table-3. The best safety performances were on projects that frequently updated project schedules.

2.8.9. Recommended Traits & Practices of Ideal Contractor

Based on the extensive literature study, following construction planning and scheduling related organizational traits & practices are recommended for the Benchmark Contractor.

Traits:

I) Functions:

1. To finish the project on time.
2. Continuous and unremitting flow of work without delays.
3. Reducing the volume of rework.
4. Limiting the confusions and misapprehension.
5. Up to date knowledge of proceedings of the project by all members.
6. Meaningful and timely reports to management.
7. Clear comprehension of who does what, when and how much.
8. Integration of entire work to make sure a quality project for the owner.
9. Authorities run the project instead of being run by the project itself.
10. Acquaintance of the scheduled times of key parts of the project.
11. Knowledge of division of costs of the project.
12. Accountability of the individuals, there responsibilities and powers.

II) Best Location in the Organization: -

This best location is, Chief planning and scheduling engineer reporting directly to the "Vice President" of the firm. Who in turn will be answering to the Chief Executive.

III) Key Players in Safety Department: -

- Chief Planning & Scheduling Engineer
- Project Scheduler
- Scheduling Assistants

IV) Duties of Chief Planning & Scheduling Engineer:-

- General Duties
- Specific Duties
- Progress Monitoring
- Management Coordination

V) IT Technology employed: -

A Planning & Scheduling department should employ any of the mentioned Planning and scheduling Software's to add weight to its work and to make the more presentable:

• Primavera Project Planner P3
• Microsoft Project
• Primavera Suretrak
• Project Scheduler
• AutoPROJECT
• CA-SuperProject

Primavera Project Planner **P3** is the most widely used planning and scheduling software package, followed by Microsoft Project.

VI) Techniques Utilized: -

Critical Path Method (**CPM**) is the most widely followed and largely unimpeded adopted technique for planning & scheduling by construction contractors universally.

Program Evaluation & Review Technique (**PERT**) is next in hierarchy of techniques being currently practiced.

VII) Relation with Other Departments: -

Contractor planning and scheduling department will have direct contacts and also have affects of its practices on Cost Estimating, Safety, and Construction Quality Departments.

Planning and scheduling department specifically shares a distinct relation with Cost Estimation and Construction safety counterparts. While the total duration and schedules directly effects the cost estimates. The schedule duration and updates has an immense impact on overall safety.

Best Practices:

1. Planning & Scheduling Should start at the project conceptual stage to:
 - a) Maintaining Solid and Consistent Cost Estimates
 - b) Instant Evaluation of Changes
 - c) Establishing Financial Needs
 - d) Measuring Results
 - e) Storing Historical Data
 - f) Training newcomers
2. Routine Updating and Monitoring of Schedule is very important, for best timely & safe conclusion of project.
3. Eloquent internal communication between all the individuals participating.
4. Documented report of daily activities to support schedules.

2.9. Quality Control Department

2.9.1. Introduction

It is not adequate that a project is accomplished on time and within the stipulated budget. It must also conform to its predetermined specifications and other requirements, referred to as the “quality” job.

Quality can be elucidated as an essential or distinguishing attribute of something or someone. *Philip B. Crosby*, one of the leading quality consultants adduced quality as “conformance to agreed-upon requirements with out hassle”. It is an important ingredient of success, in all the things we do. As construction industry being more in craved for perfection, where it is critical that no failures occur, it is the appropriate area for implementing applications of quality system. *Thorne, Henry* (1990) adduced that, there are four basic quality rules:

- Quality is defined as conformance to requirements
- The system for causing quality is prevention of defects
- The performance standard is zero defects, and
- The measurement of quality is the price or cost of non-conformance.

Construction quality management is the performance of tasks which ensure that construction is performed according to plans and specifications, on time, and within a defined budget. The construction contractors are the responsible for controlling quality of

the work. Coordination and cooperation with the contractor assures that the quality set by the plans and specifications is achieved (U.S. Navy Web Site)

Quality Management is that aspect of the overall management function that determines and implements the quality policy. *Project Management body of knowledge*, (1996) cites that project quality management includes the processes required to secure that the project will satisfy the needs for which it was undertaken. It includes “all activities of the overall management function that establish that quality policy, objectives, and responsibilities and implements them by means such as quality planning, quality control, quality assurance, and quality improvement, with in the quality system”.

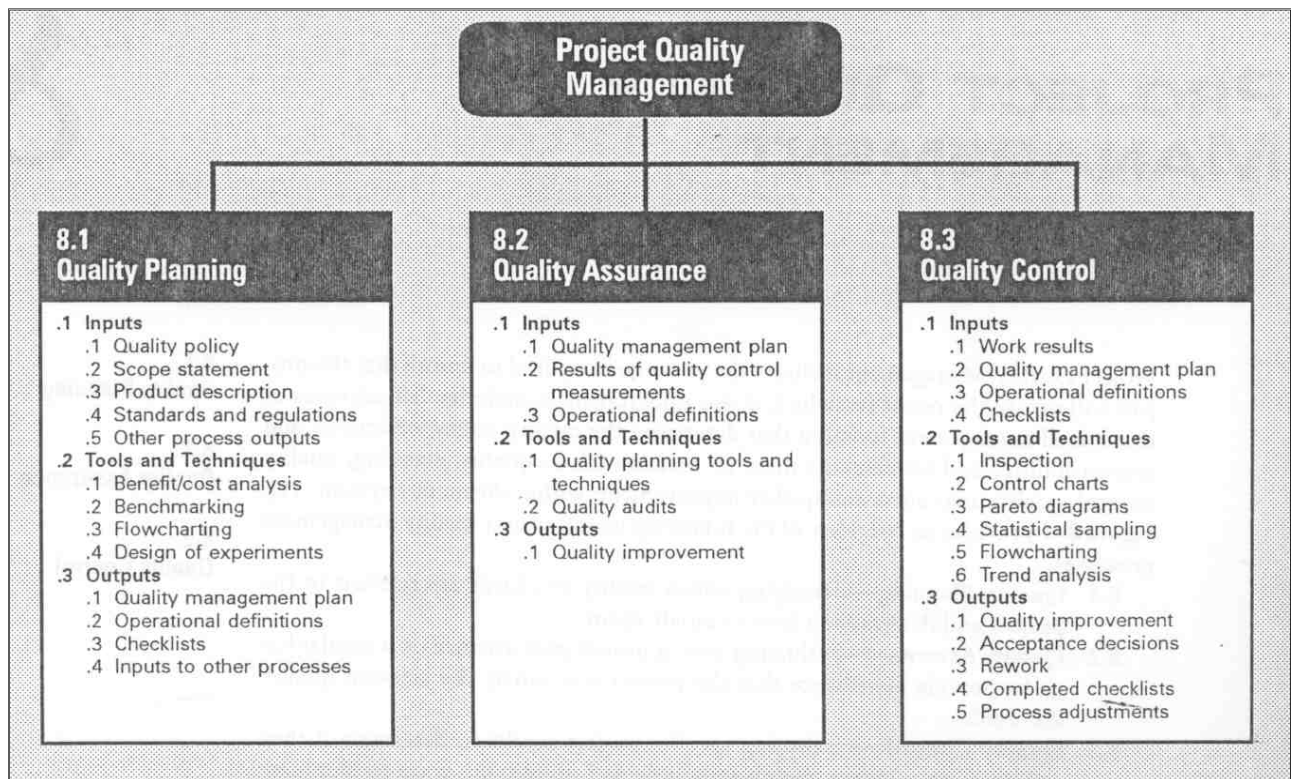


Figure 2.10: Outline of Project Quality Management Processes (*Project Management Body of Knowledge, 1996*)

Quality Planning: Quality Planning aims at identifying which quality standards are relevant to the project and determining how to satisfy them.

Quality Assurance: All the planned and systematic activities implemented within the quality system that can be demonstrated to provide confidence a product or service will fulfill requirements for quality.

Quality Control: The operational techniques and activities used to fulfill requirements for quality.

2.9.1.1 Incentive for Construction Quality System

There are four essential factors which determine whether a project will be lucrative are cost, schedule, safety and quality.

Quality systems exist for the benefit of the procurer as well as the producer. The procurer is concerned with quality in terms of the application of the product for its particular use. From the contractor's point of view, he has to satisfy the owners and meet his expectations or the product will not be marketable. At the same time, control his organization to produce a construction, economical and on schedule.

Neese & Ledbetter (1991) articulated that quality in the engineering and construction industry has become a key issue in today's economy. The spur behind this was the wide acceptance of globalization, which resulted in threat from more quality conscious foreign competition.

2.9.1.2 Total Quality Management (TQM)

Total quality management is a company-wide effort that comprises each and every one in an organization in an effort to improve performance. It permeates every aspect of a company and makes quality a primary strategic objective. TQM is accomplished through an integrated effort among personnel at all levels to increase customer satisfaction by continuously improving performance (*Burati et al.*, 1991).

TQM requires that the principles of quality management should be applied in every branch, and at every level, in the organization with an stress on integration into business practices, and a balance between technical, managerial and people issues (*Dale*, 1999).

According to *Al-Sulimani & Sharad* (1994), TQM is varyingly called a program, a process, the Deming's way, and a matrix involving top management support, employee empowerment, a teamwork, and quality assurance.

As per *Dale*, (1999), the key elements of a successful TQM program include the following:

- Commitment and leadership of the CEO
- Planning and Organization
- Using tools and techniques
- Education and training
- Involvement
- Teamwork
- Measurement and feedback

2.9.1.3 Location of the Quality Function in the Organization

The size and role of the quality function within the organization, and its relation to other departments, influences the deployment of the quality guidelines and its integration with other aspects of the organization (*Dale*, 1999).

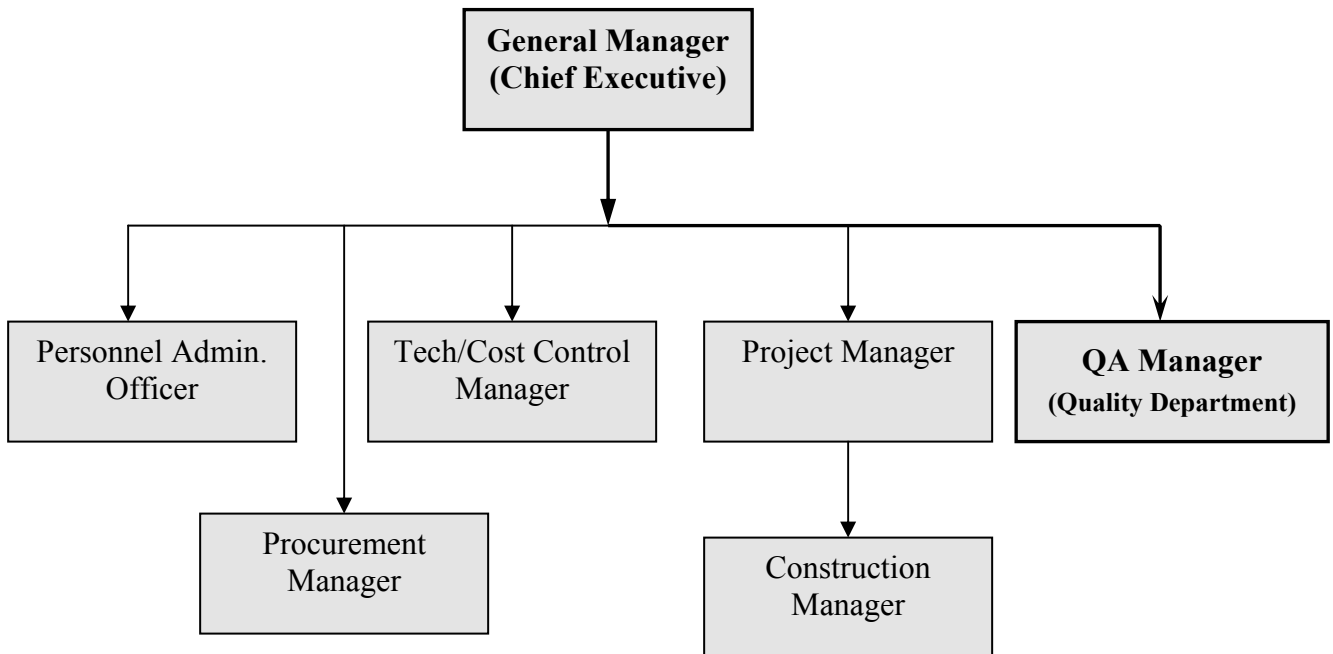


Figure 2.11: Example management Organization showing the suggested Location of Quality Management department

To keep the project economical, the most important decisions regarding the quality of a completed facility are made during the design and planning stages rather than during construction. Therefore, the quality department should position itself such that it can have its impact right from the preconstruction phase (*Hendrickson et al., 2000*). Quality control during the construction phase largely deals with insuring conformance to this original design and planning decisions.

2.9.2. Cost of Quality

Understanding and determining the cost of quality lay the foundation for quality improvement in any contractor firm. It shows the financial benefit of doing things right

the first time. In his study *McConachy* (1996) referring to a book expressed that best measurement for quality is money.

The cost of quality is important element to be considered for the management of quality. Cost of quality includes costs of all actions required to assure that the construction site being developed meets the requirement of the customer. The cost of quality includes quality management costs and deviation or hidden costs (*Heisler, Thorne. et.al.*).

The Construction industry institute (CII), concerned about need of information regarding engineering and construction conducted an analysis on nine industrial type projects, which indicated the cost of failing to meet the quality standard are in the range of staggering 12 to 15 percent of total project costs (*Neese & Ledbetter, 1991*).

2.9.2.1 Quality Management Cost

Quality Management Costs encompass all costs associated with quality assurance and quality control. In general terms, these are the prevention and appraisal costs. These costs sum up approximately 1 percent to 3 percent of the cost of production. The following costs fall in the bag of quality management costs (*Heisler, Thorne. et.al.*).

- Wages and benefits associated with the quality organizations, both project and home office
- Quality program development
- Quality orientation and training

- Formal design check and review
- Other document check and review
- Preparation of quality documentation
- Materials inspection and testing
- Work inspection
- Quality reporting
- Post-project reviews
- Miscellaneous

2.9.2.2 Deviation or Hidden Costs of Quality

Deviation or hidden costs are the expenses in addition to quality management costs that are necessary to maintain quality both during the construction and thereafter. They constitute costs of all rework and subsequent impact costs of those rework. Rework cost in the engineering and construction industry can be significant. Normally the hidden costs will be much larger than the aforementioned quality management costs (*Heisler, Thorne. et.al.*).

.These costs are the results of engineering errors and omissions, owner-operator changes, salesperson changes, contractor changes, miscellaneous. The hidden costs associated with quality are incurred:-

- In process rework

- In process scrap
- Delays and rerouting for rework
- Retesting
- Warranty repair and replacement
- Miscellaneous.

2.9.3. Contractor Quality Management Department

The contractor quality department is one four key project management elements for the successful operation of the contractor firm. The aim of the quality department will be to establish an effective quality system in its organization.

The key focus of the contractor quality department will be define the functions, roles, responsibilities, hierarchies, boundaries, flexibility and innovation of all the associated individuals (*Dale, 1999*).

Dale, (1999); adduced that ISO8402 defines quality system as an organization structure, procedures and resources needed to implement quality management. The purpose of a quality system will be to set up a framework of reference points, to ensure that every time a process is performed the same information, methods, skills and controls are used and applied in a consistent manner.

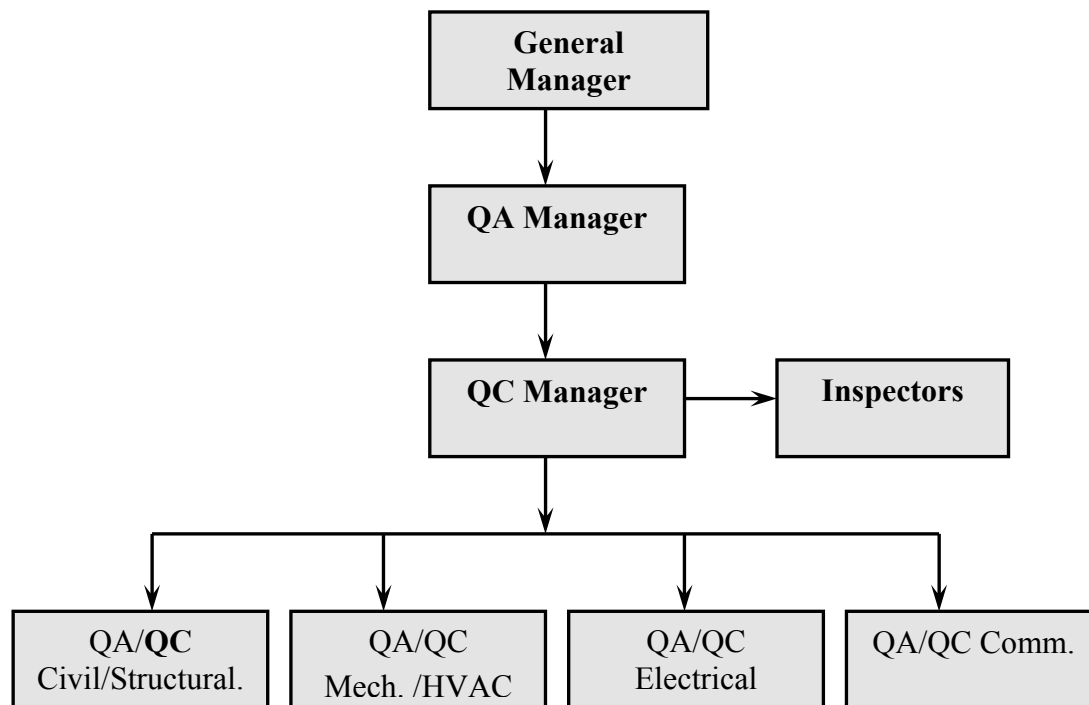


Figure 2.12: Example showing the suggested Organization of Quality Management Department (Developed from Literature Study)

2.9.3.1 Key Players in Contractor Quality Management

Everyone has an influence on quality line workers, middle management, support staff, and senior executives. Construction quality management is a company-wide effort that requires everyone in an organization in an effort to improve performance. It permeates every aspect of a company and makes quality a primary strategic objective. Total quality management is achieved through a combined effort among personnel at all levels to increase customer satisfaction by continuously improving performance (*Burati, Matthews et al.* 1991).

Hendrickson et al. (2000); suggested that quality control should be a primary objective for all the members of a project team. Managers are primarily responsible for maintaining and improving quality control. Employee participation in quality control should be sought and rewarded, including the introduction of new ideas.

According to *Dale*, (1999) without the total demonstrated commitment of the CEO and his/her immediate executives and other senior managers, nothing much will take place, and anything that does will not be permanent. He further adduced that the managers shall take charge personally, lead the process, provide direction, exercise forceful leadership, including dealing with those employees who block improvement and maintain the momentum.

Quality Managers:

Prior to this resurgence in the importance of quality, the role of a quality manager in most cases was one of police officer. The importance of a quality manager in an organization has significantly increased since then.

If quality of construction is to be managed in a firm, it must first be understood. It frequently points in the wrong direction or is otherwise incomplete. If managers are to succeed, they must first move aggressively to improve their understanding of quality practices and performance. The quality managers need to acquire more detailed information about their own quality performance (*Chen et al.*, 2000).

2.9.3.2 Construction Quality Aspects

The quality of construction is the level of conformance of the features of the facility to the client's needs. From the contractor's point of view, it's the degree to which the constructed facility delivered by the contractor is consistent with drawings and specifications.

But in his study *Yasamis et al.* (2002) cited some research to suggest that the quality in construction should be expanded to include the performance of the company as a whole and the client satisfaction derived from that performance. The figure-3 put forward a comprehensive view of quality that deals with both the service and product related aspects of the construction project, together with the corporate quality culture in place in the construction contracting firm.

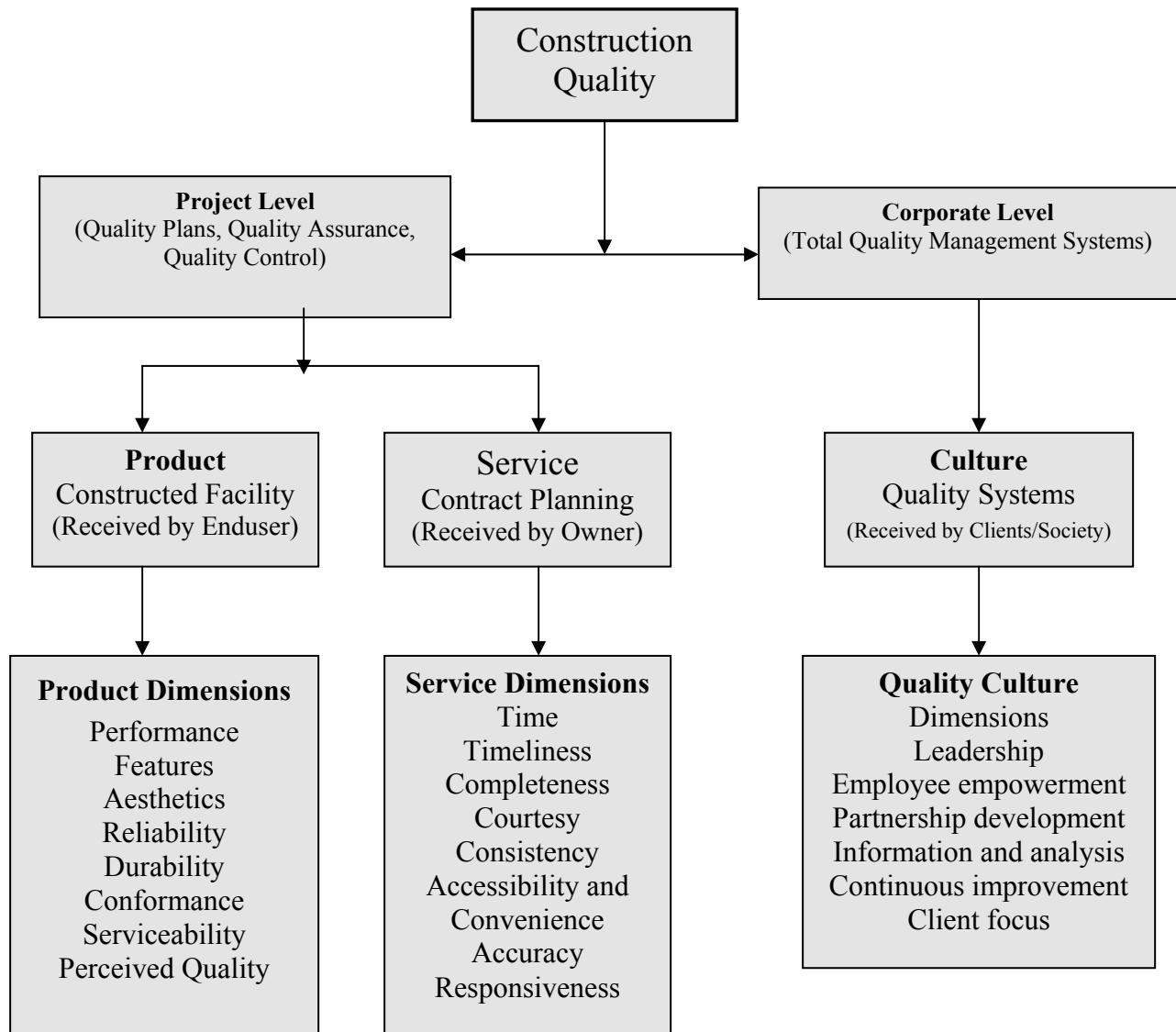


Figure 2.13: Example depicting the comprehensive view of Construction projects quality aspects (Reformulated from Yasamis et al. (2002)).

Corporate-stage quality aspects:

Corporate-stage quality cites to the quality expected from a construction company in addition to the product and service quality. A corporate quality culture is the

organizational value system that encourages a quality-conscious work environment. The presence of strong quality culture helps a contractor achieve client satisfaction as well as sustaining competitive advantage by delivering higher quality service and producing higher quality facilities (*Yasamis et al.*, 2002)

To describe corporate-stage construction quality, (*Yasamis et al.*, 2002) compiled a list of quality attributes that should exist in a contractor company including:

- Leadership
- Employee empowerment
- Partnerships development
- Information and analysis
- Continuous improvement
- Client focus

These attributes forms the fundamentals of a successful total quality management system, and are representative of the general characteristics of a quality alert organization. These traits are expected to increase the client satisfaction of construction industry by providing an infrastructure for quality improvements in company operations.

Project-stage quality aspects:

The fields of construction work, including material and component selection, on-site project quality, project management activities, and project quality management systems are the responsibility of the contractor.

Project quality systems deal with the management of the quality aspects of the project. They are inspired by the quality system of the corporation. Project quality systems comprise following documented practices, not tolerating deviations from plans and project controls, avoiding paramount confidence, thinking ahead in project plans and making provisions for deviations before they turn into quality problems in quest to getting things done right the first time, every time and inculcating quality management into all actions of the project staff (*Yasamis et al.*, 2002).

The customer satisfaction experienced with the constructed facility and the contracting service defines project-stage quality in construction. (*Yasamis et al.*, 2002) suggested that quality in construction projects includes a mix of product and service quality dimensions including:

PRODUCT QUALITY:
Performance
Features
Reliability
Conformance
Durability
Serviceability
Aesthetics
Perceived quality

SERVICE QUALITY
Time
Timeliness
Completeness
Courtesy
Consistency
Accessibility and convenience
Accuracy
Responsiveness

It is projected that a contractor will conform to minimum requirements in all dimensions of project quality while excelling at some, based on its past experience and core competence. These factors also will act as benchmark for comparing the contractors future performance in each dimension, while creating a universal scale of measurement. The categorization of the construction project into its product and service components facilitates the identification of quality traits in the construction project(*Yasamis et al.*, 2002).

2.9.4. Company Quality Management Program

Quality systems benefit the producer as well as the user, but this requires that quality standards be set and that they be measurable and quantifiable. In most cases a quality program is necessary; a proper program will deliver significant results for a modest cost. Simple, well lucid participative programs are the key to high quality performance.

As per *American society for quality*, a company quality program is a document or set of documents that describe the standards, quality practices, resources and processes pertinent to a specific product, service or project.

2.9.4.1 Necessity of Quality Program

A well developed and proficient quality program is and essential factor for successful and fruitful working of the contractors quality department. An added factor that prompts the implementation of quality program is that quality standards do not stand still.

They are continuously evolving and improving, this is true in construction and other fields too.

Heisler (1989) suggested that one way of gauging whether a formal quality program is needed is to compare our firm with the competition. This approach will provide an idea, whether changes are necessary and, most importantly, the area in which improvements should be made.

Generally there are three situations which lead to cause quality programs to be instituted; they are including (**Heisler**, 1989):

- Quality programs are obligatory because of regulatory requirements.
- Quality programs are sometime required in case of government projects, and
- Quality programs self-initiated because of concern for the performance of the organization

2.9.4.2 Quality management program essentials

The following are the essentials for a successful quality management program (**AACE**):

Quality Culture:

According to the Association for the advancement of cost engineers, For a contractor organization to continually produce products and service of high standards, a quality culture and attitude is needed within the organization and applied to all activities.

Quality Goals:

Every single individual working for an organization, will be more motivated when working toward some worthwhile goal and seeing progress against that goal. Quality experts believe that “zero defects” should be the goal of any quality management program. Some Examples have also suggested that zero defects are also achievable without cost (*AACE*).

Emphasis on People:

The link in the quality chain that has the highest possibility for failure is the human link; it is relatively easy to keep track of materials and others. Thus, management must concentrate their attention on the people factor. As per *AACE* a quality person is the individual who has the skills, knowledge and motivation required to properly perform the task. A quality management program must foster the development and maintenance of such individuals.

2.9.4.3 Elements of quality management program

Generally the details of the way in which quality program elements are described and the specific terminology used differ among the standards, the major program elements found in the various standards are quite similar and are intended to essentially achieve the same goals.

Succeeding are the some of the key elements that constitute the part of quality management program (*Heisler*, 1989):

- A quality management program must include a documented organizational structure with clearly defined responsibilities.
- The quality management program shall be described in a program manual , which shall be timely updated.
- There need to be sufficient independence for the quality organization to identify and report problems, recommend and verify corrective action and control nonconforming material.
- Individuals performing quality related activities shall be qualified for the work they perform. The qualification can be based on education, training, experience or examination but must be documented.
- The personals should be trained and there training records shall be maintained.
- A program to ensure the quality of the construction shall be planned, implemented and updated.
- Designs shall be documented to ensure conformance to specifications and regulatory requirements.
- Responsibility for approval shall be stated in the quality program.
- Process control instructions shall be in written or graphical form include control features for particular development, acceptance criteria etc.
- The quality management program shall describe the control features to ensure conformance to procurement requirements.

The elements of the quality program may vary a bit depending to the project. An important principle that shall be remembered while designing a quality management program is to limit the scope of the same. There is no need, and in fact, a real danger of excessive cost and complication, if activities not necessary are included as part in the program. The program can always be added to by adjustment and hence there is no real incentive to make a program initially more extensive than the most necessary *Heisler* (1989).

2.9.5. Training and Education

Contractor's Quality management system performance can be effectively enhanced by adopting many proficient techniques, including by employing quality training programs. Everyone has an influence on quality including line workers, middle management, support staff, and senior executives. They all benefit from training in the principles of quality.

Employees, from top to bottom of an organization, should be provided with the right level and standard of education and training to make sure that their awareness and understanding of quality management concepts, skills and attitudes are proper and suited to the continuous improvement philosophy (*Dale*, 1999).

The study conducted by *Burati et al.* (1991) suggest that companies involved in formally implementing TQM had considerably more training efforts than the non-TQM companies. They further adduced the construction companies that developed their own

corporate TQM approach had greater success in integrating the training into the job function than companies using a singular TQM approach.

A formal syllabus of training and education is must on a timely and regular basis to enable people to cope with increasing complex problems. The training program must also focus on helping managers to think through what improvements are achievable in their areas of responsibility (*Dale*, 1999).

The research performed by *Burati et al.* (1991) revealed that the usual training topics in implementing TQM and the training received at each level of the TQM structure includes:

- TQM philosophy
- TQM implementation plan
- Interpersonal relations
- Team development
- Leadership
- Statistical methods
- Problem solving
- Organizational climate
- Meeting rules and procedures
- Presentation skills

Team work approach is important in quality management training and education, team training topics are equally balanced between technical and humanistic issues, and the

examples and problems used in the training relate to the job function of the team *Burati et al.* (1991).

2.9.6. Contractor Quality Management Practices

Studying and analyzing the current practices being followed in the industry, is the best method to know the degree to which these technique is being utilized.

2.9.6.1 Details of various Quality Management practices

(Practices of US contractors, based on research of Wolf and Hurtado (AACE, 1990), Burati et al. (1991) and other researches):-

In there study, *Wolf and Hurtado* investigated the current quality management practices. There study complimented the previous studies by other researchers in the industry. They conducted research considering that the most knowledgeable people about current quality management practice and concerns with respect to construction projects are the individuals directly responsible for achieving it.

The following are some of the key quality management practices, currently being practiced in the construction industry based on the survey conducted over 27 contractor firms of various sizes, including construction, transportation, industrial and others.

a) *Aims of Construction Quality management:*

In there study ***Wolf and Hurtado*** (AACE) identified the list of possible key aims of quality management based on literature review, namely:

• Conformance to requirements
• Know what the owner wants
• To bring project within budget and on schedule
• Elimination of error, waste
• Implementing quality assurance program
• Improvement of procedures

b) *Benefits of Quality Management:*

In there study, the contractors cited the following benefits of adopting a formal quality management program:

• Reduced rework
• Reduced cost
• Satisfied owners with final product
• Improved relations with customers
• Employee participation in problem solving
• Improved service
• Fast and efficient work
• Faster identification of problems

c) Quality management Approaches Employed:

Research conducted by **Burati et al.** (1991) revealed the following trend in practices of the different quality management approaches being employed by the contractors.

25 % of the contractors interviewed employed QA/QC approach, 75% of the contractors interviewed employed Formal TQM approach and none of them employed informal TQM techniques.

d) Apparent difficulties of adopting quality management programs:

When the researchers queried the contractors regarding the apparent difficulties of adopting quality management programs, they imparted following reasons:

• Competitive fees for firms without quality management programs
• Overcoming reluctance
• Adversarial relationship between departments
• Blocks to training quality management principles
• Slow process to bring about cultural changes
• To maintain awareness and communication

e) Efforts to identify quality costs:

When the contractors were asked whether they practice any active efforts to identify quality costs, only 25 percent of the contractors replied yes and rest seems they

don't try to identify quality costs. But the literature study suggests time and again that identifying quality cost is root to successes.

f) Quality focused education of the engineers:

When the contractors were asked whether they conduct any active efforts to provide quality focuses educate there engineers. Almost all the contractors seem to have a training session to enlighten its engineer staff. This is in conformance with peer reviews.

g) Methods Employed for Quality Education:

The AACE, survey result suggested that the questioned contractors employed the following techniques for imparting quality education to its employees.

• Formal classroom training
• On the job training
• Bring in outside consultants
• Team approach to problem solving

h) Project Activity where best Quality work is being done:

When the contractors were questioned regarding the area in which best quality work is being execute. The key areas cited by the contractors include:

• Engineering and Design

• Cost/Planning/Scheduling
• Project Control

i) Reasons cited for Best Quality activities:

When the contractors were queried regarding the reasons behind above mentioned best practices, they gave following reply:

• Well established procedures, experienced staff, better education level
• Cost-effective to implement project control
• High caliber people

j) Measures to improve quality level of projects:

When the contractors were queried regarding the measures to improve quality level of projects, they have following suggestions:

• Better communication
• Practical training
• Quality improvement process
• Monitoring
• Rational schedules
• Improved reward system
• Set high quality standards

k) Sources for Key Quality Problems:

When the contractors were queried regarding the reasons behind following mentioned key sources/areas of quality problems, they gave following views:

▪ Engineering
▪ Time Constraints
▪ Vendors / Subcontractors
▪ Coordination
▪ Communication
▪ Misunderstanding Quality
▪ Lack of experience
▪ Management

l) Measures to motivate project engineers to enhance quality performance:

When the contractors were interviewed regarding the measures to motivate project engineers to better quality performance, they have following propositions:

• Education
• Reward
• Practical project experience
• Team building/Communication
• Recognition
• Good leadership
• Accountability
• Top management commitment

m) Quality Management Attributes:

When the contractors were interviewed regarding the various quality management attributes they employed, measures to better quality performance, there practices include

• Organizational Structure
• Training
• Tools, methods, and techniques
• Contract party relations
• Contracting methods

2.9.6.2 Communicating Quality goals & Success to employees

Communicating quality goals and success stories of the individuals and teams, acts as a motivation factor to excel. *Dale* (19991) articulates that means of celebrating and communicating success with TQM should be considered, and methods developed for recognizing the efforts of teams and individuals. Every team member of the firm will feel the responsibility of TQM, if linked to providing adequate recognition, rewards and incentives for quality efforts, this also stresses the message that quality is a strategic concern is reinforced.

Recognition and communication of success can be facilitated in a number of ways, some of the tools and techniques usually employed by the construction firms includes:

- Quality News Sheets
- Team briefs
- Quality action days

- Team competition/celebration days
- Quality conferences
- Presentations by the president and / or CEO
- Supplier award days
- ‘How are we doing’ boards
- ‘Thank you’ notes
- Personal thanks
- Applause
- Allocation of shares in the company

2.9.6.3 Tools and Techniques for Excelling Quality

To assist, widen and enhance a process of continuous quality improvement, it is necessary for an organization to employ range of tools and techniques. Some of these simple tools and techniques will act as a root to excel in quality.

Sypsomos (1997) suggest that the combined use of TQM and project controls tools, not only help us arrive at the most intelligent decision, we can also set indicators to trigger an “alarm” when things don’t go well and when they exceed or do not meet an acceptable range of performance.

In his research *Raz* (1985), mentioned three primary tools for improving construction quality management, they include: An analytical technique, Group

brainstorming, Statistical Process Control (SPC). He further illustrated that analytical tool comprises of very successful technique called Cause and effect or Fishbone diagram. SPC tools comprises of quality circles, which are successfully implemented by using individuals from different parts of the organization, such as engineering, maintenance, marketing, customer service as well as production employees.

Following are some of the widely used tools aimed at total quality improvement, along with there applications *Sypsomos* (1997):

TOTAL QUALITY TOOLS AND THEIR USES			
Tool	Use	Tool	Use
Bar Chart	Analysis	Interview	Data Gathering
Barriers & Aids	Analysis/DG (DG)	Line Graph	Analysis
Brainstorming	Teamwork/DG	List Reduction	Teamwork
Cause-and-Effect Diagram	Analysis	Matrix	Analysis/DG
Check sheet	DG/Analysis	Pareto Chart	Analysis
Flowchart	Analysis	Pie Chart	Analysis
Histogram	Analysis	Survey	Data Gathering

In his research *Sypsomos* (1997) quotes that previous surveys have shown that 80% of the problems we come across on the jobs can be corrected using the three primary tools: the checksheet, Pareto analysis, and cause-and-effect analysis. He further adduced that these three, along with other quality improvement tools are used effectively during all

project management and project control phases of a project life cycle, the results in planning and controlling resources, costs, and risk will be very effective.

2.9.6.4 Information Technology in Quality

Information technology is becoming an inherent part of any contractor organization. *Bubshait et al.* (1999) adduced that proper utilization of computers for quality related proceedings can lead to decrease in the amount of doing work/rework, thus increasing the productivity of the organization. They further mentioned that the use of CAD tools lessens the amount of rework done, thus improving the productivity of the employees concerned.

2.9.6.5 Quality Models

Quality models are the established benchmarks of quality standards being taken as role models by many industries, to evaluate and rate their quality performance. Standards make an enormous contribution to most aspects of our lives. Standards play a major role in raising levels of quality, safety, reliability, efficiency and interchangeability.

As per American society of quality, the following are some of the effective quality models being practiced as role models for quality:

ISO9000 Series:

ISO (International Organization for Standardization) is the world's largest developer of standards. It is a network of national standards institutes from 148 countries working in

partnership with international organizations, governments, industry, business, and consumer representatives. A bridge between public and private sectors and, ultimately, to people in general in their roles as consumers and end users (www.asq.org).

The ISO9000 series is to give purchasers an assurance that the quality of the products and/or services provided by a supplier meets their requirements. The series of standards defines and sets out a definitive list of features and characteristics with it is considered should be present in an organization's management control system through documented policies, manual and procedures, which determines that quality is build systematically and is achieved (**Dale**, 1999).

But **Dale** (1999) also reported from Boaden et al. (1991) quoting on a study of TQM in the UK construction industry, make the point: "One of the main arguments put forward for the ISO9000 series of standards is that it will help to mitigate second-party assessments, the responses suggest that this has not happened in the construction industry, clearly a disappointment.

The ISO9000 series consists of five individual standards, namely ISO9000, ISO9001, ISO9002, ISO9003 and ISO9004, divided into four parts (**Dale** ,1999):

- Guidelines
- Model for QA in design, development, production, installation and servicing
- Model for QA in production, installation and servicing.
- Model for QA in final inspection and test.

Malcolm Baldrige National Quality Award (MBNQA)

Malcolm Baldrige National Quality Award (MBNQA) is a criteria for performance excellence as a management model, it is national quality award program in the United States, it is focused to improve quality and productivity by (www.quality.nist.gov, National Institute of Standards and Technology):

- Recognizing the achievements of those companies that improve the quality of their goods and services and providing an example to others;
- Establishing guidelines and criteria that can be used by business, industrial, governmental, and other organizations in evaluating their own quality improvement efforts;
- Helping to stimulate American companies to improve quality and productivity for the pride of recognition while obtaining a competitive edge through increased profits; and
- Providing specific guidance for other American organizations that wish to learn how to manage for high quality by making available detailed information on how winning organizations were able to change their cultures and achieve eminence."

Other major standard models that can be considered in the development of an organization's quality system, plans, and programs.

2.9.7. Relation with Other Departments

The Boundaries and barriers which are built up between departments, functions and shifts are barrier to teamwork and inter-departmental working and co-operation, which are the key elements of TQM (*Dale, 1999*).

An effective contractor organization will have an efficient interaction between its various departments for accomplishing the project with better quality in prescribed time and cost.

Quality & Safety:

Hendrickson (2000); articulates that variety of different organizations are possible for quality and safety control during construction. In case of large organizations, departments dedicated to quality assurance and to safety usually assign specific individuals to assume responsibility for these functions on particular projects. For smaller projects, the project manager or an assistant might assume these and other responsibilities.

Quality, Cost Estimating, and Planning:

One of the principles of quality managements is “if u cant measure it, you cant manage it” (*McConachy, 1996*). Cost engineers who are part of estimating department are in the measurement business, mostly for money and time.

(*McConachy, 1996*) adduced that cost engineers, the professionals involved in measuring performance and developing concise presentation for two of the three factors of conventional project quality, schedule and budget forms a bridge in between the departments of cost estimation, planning and scheduling and quality management. He

further mentioned that by measuring the cost of quality a cost engineer legitimize his involvement with quality management department.

2.9.8. Recommended Traits & Practices of Ideal Contractor

Based on the extensive literature study, following construction Quality Management related organizational aspects & practices are recommended for the benchmark contractor.

Traits:

I) Function: The functions of the contractor Quality management department are :

- Assuring conformance to requirements.
- To bring project with in budget and on schedule.
- Implementing Quality Assurance program.
- Minimize rework.
- Elimination of errors in the constructed facility.
- Providing competitive edge in the industry.
- Improvement of Procedures

II) Best Location in the Organization:

Reporting directly to the vice president of the organization and if necessary to the General Manager/Chief executive or the top management. This is practical as the top officials hold the key responsibly, for quality management, along with all the employees.

III) Key Players in Quality Management Department:

Along with all the members of the project team:

- Quality Managers
- QA/QC Managers
- Inspectors

IV) IT Technology employed:

Modern computers equipped with basic requirements. Using CAD tools will be very effective for quality as they minimized rework.

V) Relation with Other Departments:

Contractor Quality management department will have good contacts with *Cost Estimating, Planning & Scheduling, and safety Departments.*

Quality management department particularly shares a close links with the construction safety department.

VI) Company Quality Management Program: The contractor organization shall have a written Quality Plan, system or program and it shall concentrate on:

- *Quality Culture*
- *Quality Goals*
- *Emphasis on People (Employee Involvement)*

VII) Certifications:

The contractor shall be certified by any of the quality models mentioned below, while ISO9000 series is recommended:

- *ISO9000 Series:*
- *Malcolm Baldrige National Quality Award (MBNQA)*

Quality Management: Best Practices:

1. The quality-related decisions of the client have to be made *prior to the start* of construction, because they set the tone for the type and function of the construction.
2. The quality department shall require its staff to participate in a training program.
3. Contractor firm shall have full-time person(s) dealing with quality-related systems for their practice.
4. The contractor firm shall be ISO certified and should be aware of what ISO-9000 requirements are.
5. The contractor organization shall have a written Quality Plan, system or program.
6. Implementing TQM, Training program for newly hired and senior employees, is required.
7. Quality department shall, communicate Quality goals & Success to employees.

2.10. Safety Management Department

2.10.1. Introduction

Construction has always been one of the most hazardous professions. According to the construction industry institute, injuries, illness, and fatalities occur in the construction industry at a rate more than 50 percent greater than for all other industries.

According to the OXFORD dictionary, “**Safety**” is the state of being protected from or guarded against hurt or injury; freedom from danger.

In there research on important criteria’s for contractor selection, *Hatush & Skitmore* (1997) establish that, health and safety performance of contractors was among the top four important criteria’s.

Opfer Neil, (1998); adduce that construction continually ranks near the top of all industries as one of the most hazardous, as analyzed from the statistics. In context of Construction safety, *Bentil* (1990) mentioned that safety should be one of the most important concerns of all professionals involved in the construction course, including the design through construction to maintenance and operation.

In his research in construction safety procedures and practices, *Knack* articulated that safety and profit have an integral relationship, the mere discussion of safety itself would become a debatable question for discussion if the construction companies are not drawing profits.

Incentive for Safety Management:

Contractors, Engineers, construction managers supervise different types of projects, all of which deal with daily new challenges, with different dangerous activities that risk human lives. These risks's always emphasizes on the importance of safety.

Martel & Moselhi (1988) sited in there research, three primary safety management incentives for the top management inclusive of:

- Humanitarian concerns
- Insurance and other costs of accidents; and
- The company safety image.

Ahmed Syed (2000) revealed in his study that, according to certain research findings, those who spend their working lives on construction sits have a 1 in 300 chance of being killed at work. In addition to this the chance of being disabled is the highest compared to other fields.

In his research ***Maccollum David*** (1995) stressed the importance of efficient construction safety management, he revealed that in united states, construction workers comprise less than 5 percent of total national work force but alarmingly sustain around 20 percent of the total workplace deaths and injuries. He further supported his point by illuminating about high construction fatality rates in various countries as portrayed in Table: 2.3.

TABLE: 2.2 Construction Fatality Rate Per 100, 00 workers; *Maccollum David* (1995)

CONSTRUCTION FATALITY RATE PER 100,000 WORKERS		
Country	Rate	Lives Lost
United States	39	2,300
United Kingdom	15	874
Greece	16	943
Finland	18	1058
New Zealand	18	1058
Spain	24	1426
France	30	1771

2.10.1.1 Price of Construction Cataclysm

Considering the profit standpoint of construction safety is not lacking of humanitarian concern, as long as we consider safety profitable not only to the employer but also to the entire workforce.

Bentil Kewku, (1990) articulated that, the cost of construction-related accidents is very high, considering the humanitarian and economical elements associated with it.

Ahmed. Syed (2000) revealed that according to certain research, the amount of money spent on construction site safety amounts 5 percent of the total contract sum. The benefits, contractors accrue from having a satisfactory safety management system in place far outweigh the costs.

According to *Bentil Kewku*, (1990) cost of accidents in construction industry can be broken down into two main categories, Direct cost or Insured Cost and the Indirect cost

or Uninsured Cost. The department safety and health of the mechanical contractors association of America, considers three key areas when examining the profitability of safety, including the direct costs of accident, indirect cost and the costs of developing and implementing a safety program.

Direct Cost:

The reason for need of effective safety management for construction companies is justified, as companies have high direct and indirect costs, and management can control these costs.

Direct costs, also know as insured cost include medical costs and other workers compensation insurance benefits as well as liability and property-damage insurance. Among the direct costs, the claims under workers compensation, the insurance that covers workers injured on the job, constitutes the major portion (*Levitt, Samelson; 1987*).

Direct costs, are not particularly a fixed amount in most of the construction industries. They vary depending upon each company's job approach.

Insurance or Direct costs are tied to contractors jobsite safety record. As the contractors number of safety related incidents drops, a figure known as the experience modification rating declines as well.

According to *Knack*, direct cost can be comprehensively classified as under:

INJURIES	PROPERTY DAMAGE (INSURANCE PREMIUMS OR CHARGES FOR)
1. Compensation for lost earnings	1. Fire
2. Medical and hospital cost	2. Loss and Damage
3. Awards for permanent disabilities	3. Use and occupancy
4. Rehabilitation costs	4. Public liability
5. Funeral charges	
6. Pensions for dependents	

Indirect Cost:

Indirect costs also known as noninsured costs include all the hidden and other costs, they are much larger part of economic burden on the contractor. According to *Clough and sears*, (1994) these indirect costs can range from four to as much as twenty times greater than the direct costs. *Knack* (1980) articulated that uninsured costs are approximately nine times greater than insured costs.

Indirect costs of construction accidents consist of first-aid expenses, damage or destruction of materials, cleanup and repair costs, idle machine time, unproductive labor time, spoiled work, equipment damage, schedule disruptions, loss of trained manpower, work slowdowns, wages paid to injured workers, adverse publicity, administrative and legal expense, lowered employee morale and other expensive side effects (*Clough and sears*, 1994)

Hidden costs are usually very difficult to trace and locate, as (*Levitt, Samelson;* 1987) mentions, the hidden costs of accidents are not only recorded rarely but also some of them are very hard to quantify. It's impractical to assign a system of cost estimate to calculate the same.

According to *Knack*, indirect or uninsured cost can be comprehensively classified as under:

INJURIES	WAGE LOSSES
• First aid expenses	• Idle time of workers whose work is interrupted
• Transportation Costs	• Man-hours spent in cleaning up accident area
• Cost of Investigations	• Time spent repairing damaged equipment
• Cost of Processing reports	• Time lost by workers receiving first aid

PRODUCTION LOSSES	ASSOCIATED COSTS
• Product spoiled by accident	• Difference between actual losses and amount recovered
• Loss of skill and experience	• Rental pf equipment to replace damaged equipment
• Lowered production of worker replacement	• Surplus workers for replacement of injured workmen
• Idle machine time	• Wages or other benefits paid to disabled workers
	• Overhead costs while production is stopped
	• Loss of bonus or payment of forfeiture for delays

OFF THE JOB ACCIDENTS	INTANGIBLES
<ul style="list-style-type: none"> • Cost of medical services 	<ul style="list-style-type: none"> • Lowered employee morale
<ul style="list-style-type: none"> • Time spent on injured workers welfare 	<ul style="list-style-type: none"> • Increased labor conflict
<ul style="list-style-type: none"> • Loss of skill and experience 	<ul style="list-style-type: none"> • Unfavorable public relations
<ul style="list-style-type: none"> • Training replacement worker 	
<ul style="list-style-type: none"> • Decreased production of replacement 	
<ul style="list-style-type: none"> • Benefits paid to injured worker or dependents 	

2.10.1.2 Location of the Safety Function in the Organization

Traditionally, the objectives of project management have been to establish a balance between schedule, cost and quality. But with the advent of new rules and requirements of the act for prevention and the steadily rising cost of workers compensation premiums, construction contractors have to include safety function as an fundamental part of project planning (*Martel & Moselhi*, 1988).

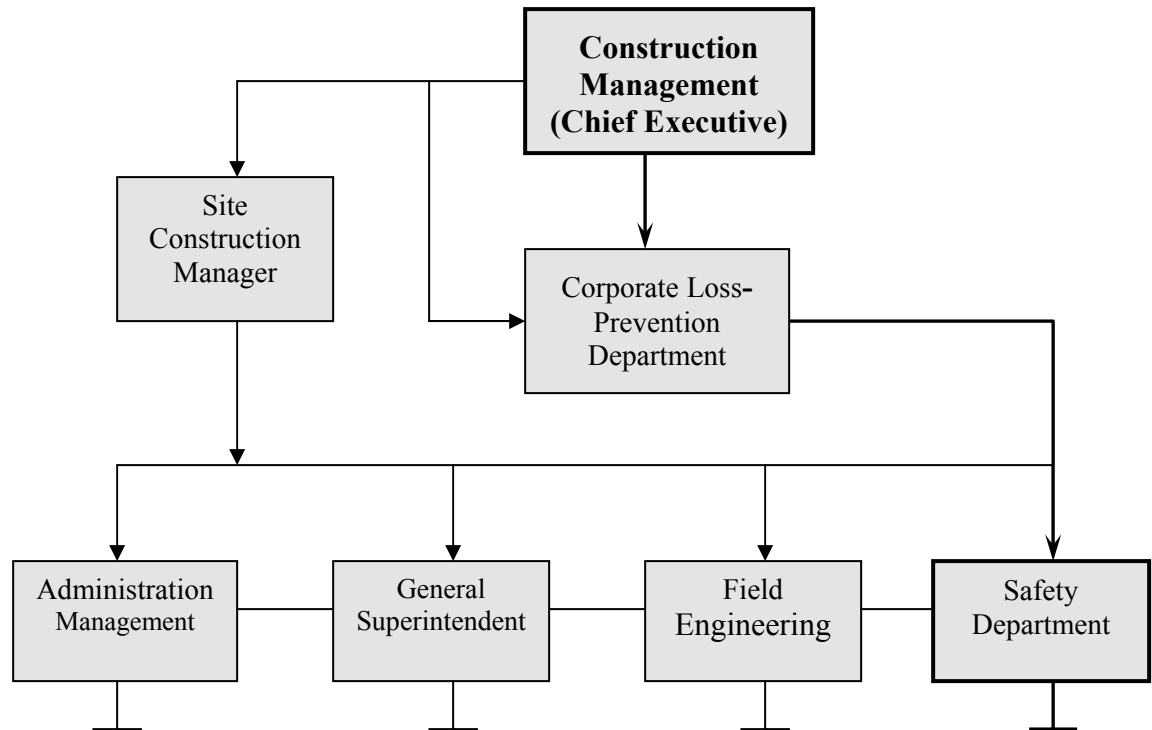


Figure 2.14: Example management organization showing the suggested Location of Safety department

Grimaldi & Simonds (1989) noticed in their research that there exists a wide variation in the location of the safety department or safety specialist in the various company organizations. They further states that this variation in position does not undermine the importance of the safety department in the overall organization. Actually, the mere changing of the safety workers location, making him report to different individuals depending on the job type, marked improvement in the safety performance in some firms.

In there research *Grimaldi & Simonds* (1989) referred to the survey over 160 concerns, conducted by cutter and it revealed that 33 percent of the companies, safety was an independent department reporting directly to the top management.

2.10.2. The Contractor Safety Department

The responsibility for the safety of employees and others involved in construction is invariably the duty of each and every individual related to the job. The role of management, specifically employed for, in a safety department is to provide expert guidance top management, project management, foremen, and workers.

According to *Davies and Tomasin* (1990) the chief executive, managing director or senior partner must assume responsibility for the safety policy and he normally sets up an organization to assist him. They further adduced that it is common practice in organizations of more than about 50 recruits for the chief executive to appoint one of his senior contemporaries as safety director to take special responsibility for safety on the management board.

Usually safety director is accompanied with other duties, his primary job is to set up and maintain an organization to propagate the safety policy and keep the boards of management committee enlighten on all safety matters.

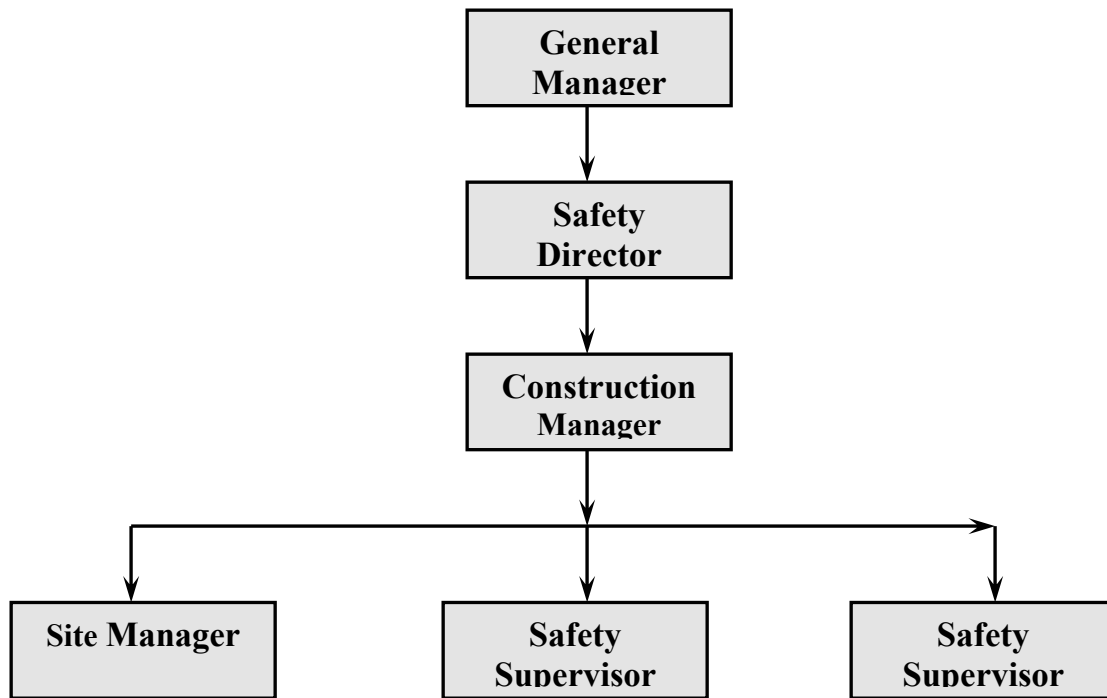


Figure 2.15: Example showing the suggested Organization of Safety Department (Developed from Literature Study)

Davies and Tomasin (1990) mentioned that from a contractors point of view the principal objective of the safety organization is the prevention of accidents on construction sites and the organizational chart has to show the line management responsible for achieving this. Generally, all the directors of the safety department are responsible to the chief executive for the safety of the sites under their control and that responsibility is carried down through.

2.10.2.1 Key Players in Contractor Safety Department

Safety Director:

The safety director is one of the important players for the successes of an safety department. Usually the company safety policy statements hold the duties and responsibilities of all the candidates and as per a safety director must ***Davies and Tomasin (1990)***:

- Ensure appropriate information, instruction and training for all staff and operatives.
- Manage a safety organization, appoint suitable staff and provide them with terms of reference.
- Provide facilities for first aid and welfare.
- Compile annual budget estimates for safety, health and welfare facilities and manage funds.
- Take accountability for reporting injuries, diseases and dangerous occurrences and keep the board regularly informed of such events.
- Verify the standard of safety committees proposed by staff.

Requisites of Safety Director:

The education of experience of people serving as safety specialist is essential for well being of department. Some of the requisites for a safety director are as under (***Grimaldi & Simonds, 1989***):

- Specific Knowledge (Knowledge of Hazards, Safety Principles, and Techniques)

- Knowledge of Engineering
- Knowledge of Business Administration
- Other Personal Traits (Enthusiasm, altruism, etc)

Construction Manager

Regarding the responsibilities of construction manager in regards to safety, there are number of sites each under the control of a site manager. *Davies and Tomasin (1990)* articulated that construction managers must make sure that adequate consideration has been given to site health and safety scrupulously, and that the safety department in particularly is made available to the site manager.

They further mentioned that construction managers must also see that the site managers have been thoroughly trained in their duties for health, safety and welfare matters and that the duties are carried out.

Safety responsibilities of the Site Manager:

Site manager is the key personnel responsible to organize the site in such a manner that it is safe both for company employees and other persons who may be affected by the same. The duties of site manager includes *Davies and Tomasin (1990)*

- Appoint the necessary staff to carry responsibility for site safety and welfare and to provide them with the authority.
- Provide time and funds for safety measures.

- To make sure that all staff and operatives have the necessary training and follow correct working measures.
- Provide protective clothing and safety equipment where necessary.
- Organize for the company and safety adviser to set up a site appraisal.
- Ascertain that the procedures to be adopted in the event of an accident are clearly understood.

Safety responsibilities of the Safety adviser or officer:

According to ***Davies and Tomasin (1990)***, under the construction regulations 1961, employers of more than 20 workmen, whether they are employed on one site or several sites, must appoint a qualified person, or persons, to advise on safety and to supervise safe conduct of the work.

In the construction industry the function of the safety adviser may be as a full-time head of department in a large company or authority or a part-time professional with a small firm, and there are many variations between the two limits.

Safety advisers engaged by contractors should be thoroughly experienced in construction techniques and legislation and preferably qualified by membership of the institution of Occupational Safety and Health. The safety adviser is responsible to the safety director, who provides his terms of reference. ***Davies and Tomasin (1990)*** further mentioned that position of safety adviser is essentially an advisory one. The following are the functions of a safety adviser with a firm of contractors:-

- To advise management on its duties under health, safety and welfare legislation and any revisions to it
- Reporting on the fulfillment of the objectives of the company's safety policy
- To advise on safe working practices, safety of plant and equipment, environment health problems, protective clothing and permit-to-work procedures
- To organize safety training courses for staff and operatives.
- To carry out site safety, health and welfare audits

2.10.2.2 Techniques for Measuring Contractor Safety Performance

One of the primary duty for safety professionals is to direct the management on safety performance measures. Contractors exploit these measures to monitor their own firm, to evaluate the safety procedures and to identify problem areas.

In there extensive research on construction safety management, *Levitt, Samelson* (1987) adduced that company level safety performance measures have a number of application. Usually top managers of the construction companies employ them to gauge their own progress and to evaluate their safety record with there competitors. There are two different measures presently in practice namely, experience modification ratings (EMR) and OSHA reportable injury incidence rates.

Experience modification ratings (EMR):

EMR technique of measuring safety performance is a good technique but it has certain limitations which limit its use by contractors including:

It is not reflective of the present safety performance of a company since the latest EMR will be based on the average of the company's performance in last 2-4 yrs *Levitt, Samelson;* (1987).

Further they mentioned that EMR is not very effective for small contractors, as there EMRs will not be as good a reflection of their own claims experience as they are for larger companies. Also the new companies or new joint ventures get full rating which is incorrect.

OSHA recordable incidence rate:

Occupational safety and health administration (OSHA) recordable incidence rate is one of the effective safety performance measures which is generally available for comparisons between different contractors and companies. This rate is based on company's yearly total for fatalities, injuries, and illnesses with lost workdays and injuries and illnesses without lost work days used. The other information from time records, the number of hours all employees actually worked during the year *Levitt, Samelson;* (1987).

The formula used for this evaluation by the U.S. Bureau of Labor Statistics, Department of labor is:

$$\text{INCIDENCE RATE} = (\text{NUMBER OF INJURIES AND ILLNESSES} * 200000) / \text{EMPLOYEE HOURS WORKED}$$

Levitt, Samelson; (1987) reveals that compared to EMR, the OSHA recordable incidence rate has the advantage of being more recent and of being applicable to small companies as well as to medium-sized and large ones.

2.10.2.3 Size of Safety Department

The number of individuals, to be hired by the department, in promoting safety varies naturally with the size of the firm and the nature of its sites and construction activities.

It is common practice in organizations with more than about 50 employees for the chief executive to appoint one of his senior colleagues as safety director to take special charge for the safety on the management board (*Davies & Tomasin*, 1990). They further mentioned that in small companies the chief executive may carry out these functions himself.

According to *Grimaldi & Simonds* (1989) the provision of a full-time safety director often gives a remarkable lift to a safety program, diminishing returns are likely to occur as the department grows and assistants are provided. But an assistant to the director usually cannot contribute nearly as much as does the first full-time expert. They further mentioned that, for the aforementioned reason, it is wise to be liberal with the money needed to hire a full-time safety director, but it is equally recommended to be conservative in hiring additional subordinates.

2.10.3. The Company Safety Program

Company safety program is an important element for over all safety behavior of the firm. An effective safety programs are the outcome of planning, coordination, and commitment by all employees of a company, from the worker at the lowest in the hierarchy to the highest official.

A written safety program is just as much a part of a contractors business as estimating and procurement. *Clough & Sears* (1994) stresses the importance of company safety program, which should include:

- The company's safety organization
- Safety training and personal protection
- First aid training
- Fire prevention
- Safety record keeping
- Jobsite inspection
- Accident hazard reporting

Clough & Sears (1994) further mentions that company safety plan must be aimed at identifying specific job hazards and educating the employees to conduct their work in line to minimize the risk of injury. Research statistics suggest that 85 percent of all construction job accidents are the direct result of unsafe behavior and rest 15 percent of all

such accidents are the result of unsafe conditions. There fore eventual aim of the firm's safety program should be to put an end to construction accidents of any sort.

Knack divulged that an effective safety programs should have five basic units, including:

1. Management support and direction
2. Safety organization
3. Worker education
4. Hazard control
5. Medical and first-aid plans

Management support and direction:

The company must issue a safety and accident prevention guidelines so comprehensive and decisive that no question remains that the program will become an on-going process **Knack**. Management must plan personnel selection, placement, and indoctrination in such a fashion that safety concerns become a way of life for all the employees. The management must maintain an active and continuing participation in the safety program.

With management support and guidance the safety program should be aimed at integration of safety into the productive system from the standpoint of materials, machines, and the people.

Safety Organization:

The fundamental of an effective safety organization is qualified safety personnel. **Knack**, suggested that a dynamic, qualified person is the key to sound accident prevention programs. Along with staff personnel, a safety organization should have safety committees representing all levels of workers and administration should be formed. These individuals will be closely associated part of system and will provide valuable assistance in locating potential hazardous conditions or unsafe practices.

A safety organization must periodically review the safety program, looking constantly for methods to improve the work environment and the handling of safety information.

Worker Education:

As the new workers are most vulnerable to injuries, the soundest safety program begins with individual job training. The fresh workers must be taught the correct way to do his job before it becomes dangerous. Safety training courses should be given to all employees and these courses should be reinforced with safety meetings **Knack**. Every opportunity to utilize demonstrations, displays, posters, exhibits, and other visual aids must be taken to keep safety on the minds of the employees.

Hazard Control:

Knack, articulated that safety inspections should be the responsibility of all the parties involved, along with safety organization every employee is equally accountable. The care of machinery and equipment must be part of hazard control. In addition appropriate maintenance of machinery is also part of hazard control. Sanitation and occupational disease control are another important part of hazard control.

Hazard control is best realized by enforcing safe practices. The rules designed to protect life and property will never do the job unless they are enforced all the time.

Medical and First-Aid Plans:

The safety organization must make and inform the workers of arrangements for hospitals, doctors, nursing, and ambulance service (**Knack**). The site should maintain proper arrangement for prompt treatment in case an accident.

He further adduced that construction company, in appraising its approach to safety, must not overlook any available source of achieving a responsive and responsible safety program. All the help available should be brought to use. It is necessary that all standards, including prevailing laws and regulations, be known to the company and its operations.

2.10.3.1 Principles for Organizing Safety Program

The contractor ought to be guided by the following principles in preparing a clear, complete, and particle safety program for a construction site (*Ahmed, S. el., 2000*):

- a. The safety program should be based on the company's safety policy, and the latter should be in full conformity with the relevant health and safety legislation.
- b. The contractor should simultaneously take into account construction requirements and health and safety on the jobsite.
- c. The contractor should inform its clients of the safety and health duties that will be expected from them on the project.
- d. The contractor should endeavor or to predict hazards and give due consideration to safety and health issues.
- e. Whenever necessary, contractors should conduct risk assessments for those site activities that are highly hazardous.
- f. The contractor should investigate site conditions carefully and collect information related to safety matters.
- g. The contractor should also consult with those persons who have relevant experience and are familiar with the site conditions.
- h. The contractor should make full use of the information at hand in proceeding with a careful analysis and a process of refinement so as to set up a complete and practicable site safety plan.

2.10.3.2 Cost of a Safety Program

A safety program for a contractor does, of course cost handsome about. A contractor cannot look on its safety program as an extra source of expense. Rather, it's an effective accident prevention program and is necessary to achieve smooth and fast functioning of job.

Clough & Sears (1994) mentions that rule of thumb is that an effective company safety program will have a cost of about 2.5 percent of direct labor expense. The truth is, however, that safety is absolutely necessary for the proper conduct of a construction business. A good point of safety program for an contractor is, that the spending of one dollar for safety can save the contractor two dollars.

2.10.4. Training and Education

Contractor's safety performance can be effectively improved by adopting many proficient techniques, including through improved safety training and better safety practices. Training and education of the various individuals related to safety and health are important accepts for proficient establishment of construction safety program.

Levitt, Samelson; (1987) in there research on construction safety management adduced that setting up an accountability system will motivate workers and supervisors to achieve good safety performance. There research suggested that training and orientation of workers and managers in safe work practices reduces accidents.

Clough & Sears (1994) adduced that the U.S. Department of labor (OSHA, Occupational Safety and Health Administration), American National Standards Institute, National Safety Council, National Society of Safety Engineers, and others provide various kinds of aid and assistance with regard to safety training and instruction.

According to *Grimaldi & Simonds* (1989) the safety education includes all implicit and explicit actions that eventually help modify knowledge, viewpoints, or behavior. Normally, administration of the safety education function in most organizations is limited to the training of the worker by the supervisor or some more experienced employee, as well as training the supervisor to the recognize hazards and take appropriate action. They further mentioned that supervisor safety training usually focus on following doctrine:

- Develop safe working environment.
- Personalize employee safety training.
- Encourage employee involvement
- Necessitate safety rules.

2.10.4.1 Importance of training new employees

It is acknowledged fact, that construction work is inherently more risky than manufacturing and clerical work. Furthermore, because of the high turnover of labor associated with many construction projects, there are always many new workers on a given site. These facts points towards the vulnerability of new workers to accidents of any

sort. Simultaneously there can be dramatic reduction in accidents simply by reducing the risk of injuries to the newest and most vulnerable workforce.

According to **Levitt, Samelson;** (1987) training new workers to be alert and aware of the dangers in the particular construction workplace in which they are being employed is an essential factor of safety. The role of the chief executive in the training area is to see that excellent training programs and materials are developed or acquired for the projects.

Levitt, Samelson; (1987) further articulated that the first priority of chief executive should be to improve safety, provision of safety training expertise and materials, and enforcement of the regular use of these skills by the new foremen and workers.

Davies & Tomasin, (1990) mentioned that many companies in the construction industry provide introduction courses for all new employees. The courses are aimed at new employees, for providing the outline of the organization and management of the company, personnel and welfare arrangements and staff facilities available. These training usually stresses on points including:

- They must read their company safety handbook.
- Observing there personal safety and safety of the equals and the community is essential; breach of the same may result in actions, including dismissal in extreme cases.
- Awareness with first aid procedure
- What to do in the event of a fire
- Steps to be followed in the event of accident
- Techniques to evacuate the building

- A brief outline of the most likely hazards employees may come across
- A brief outline of future safety training and information that is required for managers and personnel on site

2.10.4.2 Safety via OSHA

In the United States, the OSHA, Occupational Safety and health administration is the principal authority in charge for regulating occupational and health issues and also for providing safety related training to contractors.

Levitt, Samelson; (1987) mentions that safety professionals depends upon several sources of informal authority: expertise, the societal belief in the importance of safety in the workplace, the OSHA laws reflects the same.

OSHA organizes a series of training institute and education centers, which provides training specifically aimed to train safety professionals. In December 2003, OSHA announced the addition of eight more Training Institute Education Centers. They provide a four-day course, which is designed for those in the private sector interested in teaching the 10-hour construction safety and health outreach program to their employees or other interested parties. The experience shows that many contractors are preferring, employees who has experienced on 10hour OSHA training. The large and small companies also prefer there employees acquainted with OSHA safety training course (www.osha.gov).

OSHA regularly inspects sites to see if practices comply with established standards and has the authority to impose fines if standards are not met *Martel & Moselhi* (1988).

The Occupational Safety and Health Act of 1970 (OSHA) is a encyclopedic set of safety and health regulations, inspection procedures, and record keeping requirements. OSHA required that each employer provides to each of his employees a place of employment that is hazard free (*Bu-Khamsin*, 1999)

2.10.5. Contractor Safety Practices

Contractor's safety performance can be effectively improved by adopting many proficient techniques, including through improved safety training and better safety practices. Good safety practices improve productivity, and as a result, reduce the overall costs of the project and enhance its ability to maintain the schedule.

Some large companies and the government agencies, which have a lower incidence of accidents among their employees, are generally the results of better safety programs and practices *Martel & Moselhi* (1988).

In there study *Martel & Moselhi* (1988) mentioned that good management practices are essential for good safety performance. They further stated that either by professionalism or for compliance with the law, safety and health considerations must start at the design and planning stage. Based on the usual planning forethought, the succeeding main aspects have been identified as factors to be considered in planning for safety.

- Construction methods
- Sequence of operations
- Layout of the site

- Cost estimate of safety equipment and installations
- Incentive clauses in contracts
- Responsibility for program preparations
- Training of field personnel.

In response to the questionnaire survey conducted over 91 contractors in the Quebec province of Canada, the following conclusions were drawn from the various contractors of irrespective of size:-

- Safety and health considerations must be taken into account at the design and planning stages of a project and should be given importance to schedule, cost and quality.
- Employers are well aware of the safety rules and requirements.
- The total direct and indirect cost of accidents is almost three times the amount invested in prevention.

2.10.5.1 Communicating Safety goals

Comprehension of the numerous economic benefits of a good safety record has motivated chief executives of many construction firms to strive for this goal. As more owners are hiring contractors with good safety records, on discovering its economic value, the excellent safety performance is becoming an important goal for most construction firms.

Levitt, Samelson; (1987) in their research on construction safety management adduced that chief executives can improve the safety of their organizations by using proven techniques, including the communicating safety goals and also by leading their employees towards the same goal.

Management studies of the safest construction firms have found that employees in those firms feel themselves part of the strong safety culture. The culture of an organization consists of: **Levitt, Samelson;** (1987)

- Written and unwritten codes of behavior and conduct in the organization
- A shared view of a higher purpose or importance to the daily proceedings of each ordinary employee
- Description of legends about events from the firm's history

An important function of a chief executive is to be a standard bearer of the organizational culture for other employees.

Communicating safety goals to employees:

Levitt, Samelson; (1987) mentions that its duty of leader to readout safety instructions to all his managers, and also to hold all his managers accountable for the safety of every one of their subordinates. Safety goals can be effectively communicated by:

- Promoting the right people
- Talking about safety on job visits

- Taking time to attend safety functions
- Using written communications to promote safety

Arranging safety functions and taking time to attend the same is an effective way for chief executives to communicate the importance that they attach to safety **Levitt, Samelson;** (1987).

Written communications which originate from the chief executive of a contractor organization are also a proficient way to communicate the firm's concerns and priorities. According to **Levitt, Samelson;** (1987) it's a practice in many organizations, to forward a statement from the current chief executive of what the organization is about and what its guiding principles are, is issued to all new employees at the time of hiring. These introductory letters contain a strongly worded section on safety by many of the safest firms in the industry.

Contractor's Communication systems:

The efficient managers of the contractor safety department rely on more than one fail-proof communication system. According to **Levitt, Samelson;** (1987) they make use of three primary systems namely, the chain of command system, direct contact, and group meetings.

In the chain of command safety related communicating system, the managers communicate with supervisors under their direction who in turn send the information on

to their subordinates. This type of communication can sometimes be unreliable for upward communication.

The Direct contact system, an effective system of communication involves direct interaction with workers. In this system the manager walk in the job very frequently and freely contacts and speaks with any individual on the site. This enhances the efficiency of the information, gives better view of the employee's latest safety concerns and explains what they plan to do about them.

The effective job-site managers rely on meeting with different supervisory groups and with other groups of work force. This system provides a means of contacting members of a group at one time to obtain joint feedback, and suggestions. Therefore meetings can be considered as good places for safety planning.

2.10.6. Information Technology in Safety

The influx of the microcomputer and the improvements that followed has made it practically feasible for anyone to have a computer at his or her desk. This potential can really help and reduce the time of a safety manager. Computer software's and applications are diverse, with regard to safety management following applications are prominent *Grimaldi & Simonds* (1989).

Mathematical Computations:

The computers ability to solve complex mathematical problems makes it a suggested tool for safety record and statistical analysis. This application provides compact

storage for categories of injuries, environmental illnesses, the associated hazards, the time lost, costs, and the other related data.

Spreadsheets:

Safety statistics can be efficiently handled by using the general software packages for “spreadsheets” that are available for all of the commonly used personal computers. Spreadsheet enables the user to set up a table of columns and rows into which raw data can be inserted.

Word Processing:

Word processing is the most frequent use of personal computers, by preparing for communications. As the practice of safety management calls for communicating effectively, the thoughtful preparation of written information is a significant necessity.

The construction safety departments, furnished with word processing can save much time for the safety office as well as its manager.

Graphics:

The graphical representation incorporates, graphs, histograms, Pie charts, and so on transforming tedious enumerations into informative pictorials.

Disadvantages:

The use of computers and information technology in the contractor safety function predictably has few limitations. More specific among them is computers vulnerability to loose important files containing vital data due to some hardware failure, Etc.

2.10.7. Relation with Other Departments

There exists a close relation of the construction safety department with the other departments including planning and scheduling, cost estimation, quality control.

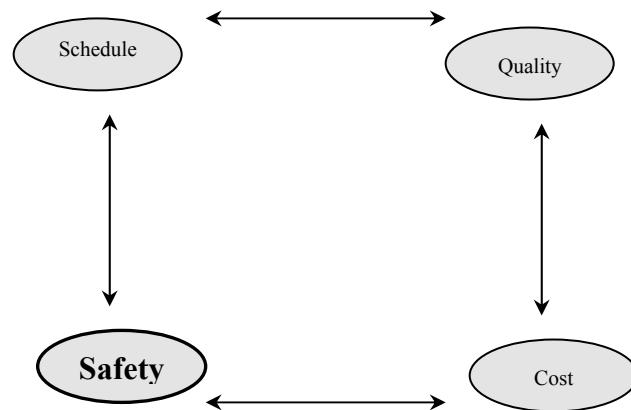


Figure 2.16: Relation Between Safety and other departments (Project Management Goals) Martel, Moselhi, 1988

Studies have demonstrated that projects with good safety performances are also likely to be well organized and mostly like finish on schedule. Both these traits lead to improved productivity and enhance the overall progress of a project, including the optimum cost and efficient overall quality.

Ahmed Syed (2000) illuminated the unrecognized advantage of good safety plan to the contractors. A safe site, with good safety regulations is likely to be a site with high morale, few disputes, less absenteeism and labor turnover, and better teamwork. Eventually resulting in better adherence to schedules, lower costs, an higher quality.

Veteto, (1994) adduced that considering the high costs associated with poor safety performances and lower productivity, it is in construction industries best interest to improve both. Subsequently they will reduce the total cost and help quality.

Safety & Planning:

Construction project safety & project planning and scheduling are the one the key functions for the successes of the project.

The relationship between project planning and construction safety is sometimes delicate, and its impact on the project is not as readily apparent as the importance of planning and safety as separate entities.

Veteto, (1994) articulated that proper use of planning techniques reduces the frequency and severity of safety incidents, this result in an improved safety record, and eventually results in lowering safety-related costs. Projects with good safety performance generally are more likely to be on schedule than those with poor safety performance, due to reduced lost time to accidents and improved overall efficiency.

In his research on relation between planning and safety, *Veteto*, (1994) further mentioned that project with good safety performances are more likely to be on-schedule than those with poor safety performances.

2.10.8. Recommended Traits & Practices of Ideal Contractor

Based on the extensive literature study, following construction safety related organizational aspects & practices are recommended for the benchmark contractor.

Traits:

I) Function: The function of the contractor safety department is to:

- Humanitarian concerns.
- Minimize Direct & Indirect costs of accidents; and
- Build up company safety image.

II) Best Location in the Organization: - Reporting to the Chief executive or top management. So that the safety related issues can be directly conveyed, resulting in swift action.

III) Key Players in Safety Department: -

- Safety Director
- Construction Manager
- Site Manager
- Safety Supervisor

IV) IT Technology employed: - Modern computers, equipped with Spreadsheets, Word Processing and Graphics, Compatible enough for Mathematical Computations”.

V) Relation with Other Departments: - Contractor safety department will have good contacts and also direct affects of its safety practices on *Cost Estimating, Planning & Scheduling, and Quality Departments*.

Safety department shares a close interaction with the planning & scheduling counterparts. A safety results depend to a large extent on project schedules and schedule updating.

VI) Company Safety Program: - The contractor should have his own safety program, which shall include:

- Management support and direction
- Safety organization
- Worker education
- Hazard control
- Medical and first-aid plans

Safety Management: Best Practices:

1. Construction Safety and health considerations must start at the design and planning stage.
2. The Safety department should hold site safety meetings for field supervisors.
3. It is recommended for contractors to follow OSHA safety rules.
4. The project safety inspections have to be carried out.

5. An efficient contractor firm must have his own written safety policy & program
6. A proficient contractor firm should conduct an orientation program for new hires.
7. Training program for newly hired or promoted foremen, is required.
8. Communicating safety goals to all the employees.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1. Research Plan

This Chapter presents the phases that will be followed for achieving the objectives set for the study. The coming sections describe the whole research methodology in detail. The purpose of this study is to Benchmark the organizational aspects of four specific functions namely Cost Estimation, Planning & Scheduling, Quality and Safety of the construction contractor. This benchmark model will serve as an excellent source of reference for contractors in Saudi Arabia and worldwide. This model will also assist in diagnosing the current construction contractors in the Eastern Province of Saudi Arabia. The research methodology constitutively distributed into following phases of research program:

1. Literature review.
2. Identification of organizational factors
3. Classification of identified organizational factors
4. Development of Potential Model
5. Reinforcing the model: Expert's Opinion
6. Development of Model

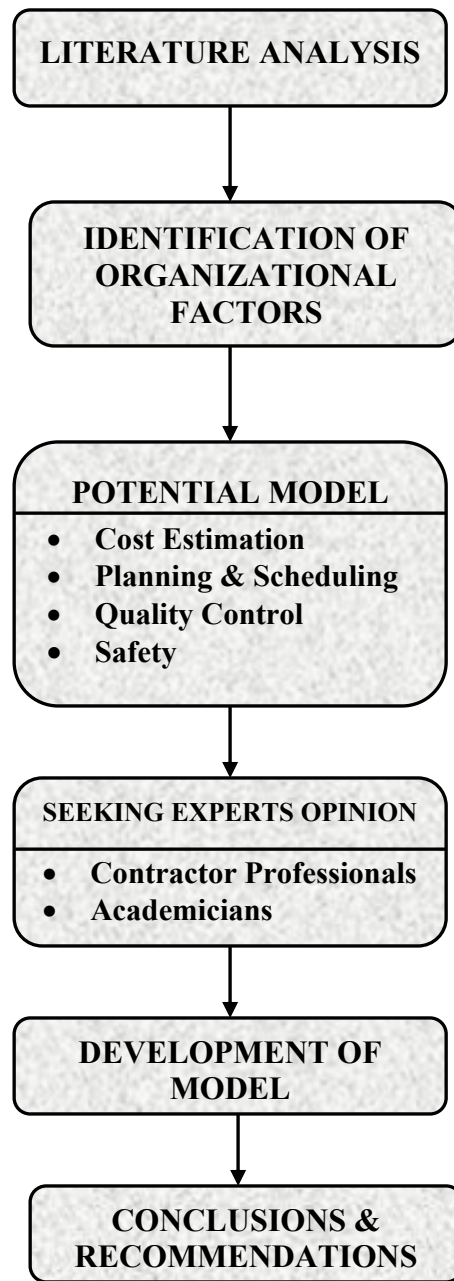


Figure 3.1: Research Methodology, Flow Chart

3.1.1. Literature Survey

The research conducted an extensive literature study. The key objectives of this literature survey were to acquire in depth understanding and immense knowledge regarding the organizational aspects of four proposed project management elements, constituting a Benchmark Construction Contractor. The Literature survey encircled the abilities and qualities conventionally perceived, which an efficient contractor is expected to prevail integrally. This knowledge eventually assisted in erecting a Benchmark Contractor. Systematic review of the detailed literature facilitated in exploring the various functions affiliated to Construction Company.

The necessary information was collected from the following areas:

- International research journals associated to Construction Engineering & Management.
- International transactions & conference proceedings from AACE & ASCE.
- Previous research in this field, masters and PhD dissertations.
- Publications and research reports prepared by various organizations like Ministry of Municipalities and Rural Affairs, Ministry of Commerce, and Chamber of Commerce.
- From numerous sources on Internet

3.1.2. Identification & Classification of Organizational Aspects from the literature analysis

In this phase of research the major organizational factors of contractor's project management elements, namely Cost Estimation, Planning & Scheduling, Quality Control, and Safety Management were comprehensively identified. These factors were identified as recognized by various construction industry leaders and professionals based on previous research and studies.

After identifying the list of major organizational factors, those factors were further studied and defined in detail. In this third phase the selected factors defining the organizational aspects of benchmark contractor were studied comprehensively, based on the former research done by construction experts. This phase specifically developed the specified functions in detail describing the inner tasks which a contractor is expected to adopt and practice. This was achieved based on the comprehensive literature review.

3.1.3. Development of Potential Model

Following to the successful identification of list of organizational aspects and further classification of each of the same, this phase of study proposed a potential model(s) and associated parameters defining those factors of benchmark construction contractor in Kingdom of Saudi Arabia. This potential model was the primary source of information for developing the final benchmark model.

3.1.4. Seeking Experts Opinion

This is one of the most important phases of the research methodology, as it incorporated a detailed corroboration of the developed potential model based on the expert opinions from selected group of prominent industry professionals in the eastern province of Saudi Arabia and the qualified academicians from the two prominent universities in the Kingdom. The principal objective of this study was to reinforce the potential model, based on the expert opinion from the aforementioned expert professionals. This study will eventually lead to the modification of the developed potential model if required.

Expert opinion included the reviews from Ten (10) prominent industry professionals, and Eleven (11) qualified academicians. Reviews from experienced industry professionals were essential for developing the overall model as these professionals are directly associated with contracting firms and its requirements. Where as the reviews from academicians are vindicated by the fact that academicians are the professionals who have strong influence on national research and scientific work.

Each expert from both contractor and academic background were approached based on their personnel expediency. Half of the responses were obtained via personnel interviews and the other half were obtained through delivering the questionnaire and collecting back the same, Post mail, E-mail and Fax.

As this phase of seeking expert's opinion consist of the walk-through observations of the selected industry professionals and academicians connected to construction

industry. These reviews provided us with qualified remarks and suggestions, which will lead to more firm and yardstick final model.

3.1.5. Development of Model

Development of model is the final research phase of this study. Data composed through expert's opinion via the questionnaire was separated and screened in this stage of the research. The data compiled was qualitatively analyzed with the developed potential model, eventually a final model "Benchmarking: Organizational aspects of contractors project management elements" is developed here.

3.1.6. Conclusions & Recommendations

The major and minor findings of the entire research are summarized in this part of the research. Based on the findings the current and further recommendations are developed as the base for further research in the very context of organizational aspects of contractor's project management elements.

CHAPTER FOUR

DEVELOPMENT OF MODEL

4.1. Introduction

The success of a contractor firm depends to a large extent on, how efficiently the projects are undertaken during the construction. This efficiency of contractor depends substantially on its organizational and working system. In a country like Saudi Arabia where there is high competition in the construction industry, number of contractor firms gets bankrupt sticking to conventional techniques and practices. This demands a serious need to develop and adopt a model defining the overall organizational aspects of the various functions in a contractor's organization.

Further to the objective of this research, a model has been developed benchmarking the “Organizational aspects of the Contractors Project Management elements”. This chapter presents the aforementioned final model. The chapter starts with description of experts including Academicians and Contractors, who are essential source of information to reinforce the potential model. The chapter also presents specifically the final model comprehensively, unfolding the recommended organizational aspects of each of the four departments.

4.2. Characteristics of Respondents

As part of research methodology of this study, seeking expert's opinion based on the potential model was one of the key sources of gathering information. The current section describes the characteristics of the participating experts, the contractors and the academicians are setting the basis for the findings of study. The mentioned characteristics of contractors includes there personnel professional experience, size of the firm they are associated with, the types of projects they involved with. The distinctiveness of academicians described include there designation, area of specialization and essentially there experience.

Experts for this extensive research are very scrupulously identified to obtain comprehensive and precise results. The highly capable experts were selected among the practicing, experienced contractor professionals from the Eastern Province of Kingdom of Saudi Arabia and the highly qualified academicians from the two renowned universities in the Kingdom. Academicians were rightly selected to seek the opinion, as they constitute the experts who carry out the research and development to benchmark the methods and systems in the industry.

Each expert from both contractor and academic background were approached based on their personnel expediency. Half of the responses were obtained through

personnel interviews and the other half were obtained through delivering the questionnaire and collecting back the same, Post mail, E-mail and Fax.

4.2.1. Academicians

Academicians are the professionals, who have strong influence on national research and scientific work. As part of this thesis, expert appraisals from faculty members belonging to Construction Engineering & Management and Civil Engineering areas from two prestigious universities in the Kingdom were ingested. More than twenty faculty members were contacted to reinforce the potential model developed from extensive literature analysis, and total of eleven highly qualified academicians dedicated their reviews to strengthen the model.

The Academicians engaged for this research are icons from academia. Their expertises are articulated by the fact that, sixty percent of the respondents are either Professor or Associate Professor from the two renowned universities. Majority of the academic experts involved are PhD holders from the most renowned universities in United States of America and the United Kingdom, a few of them received PhD from the prestigious Indian Institute of Technology.

Along with the aforementioned colossal qualification levels, the traits of the participating academic professionals include their experience, classified based on the number of years in academia. Forty five percent of the interviewed experts are dedicating their services to the academic discipline from more than 20 years. Another forty percent

of the academic experts have 10-20 years of practicing experience and the rest of the experts have around 10 years of professional experience in academia. Figure 4.1, graphically illustrates the same.

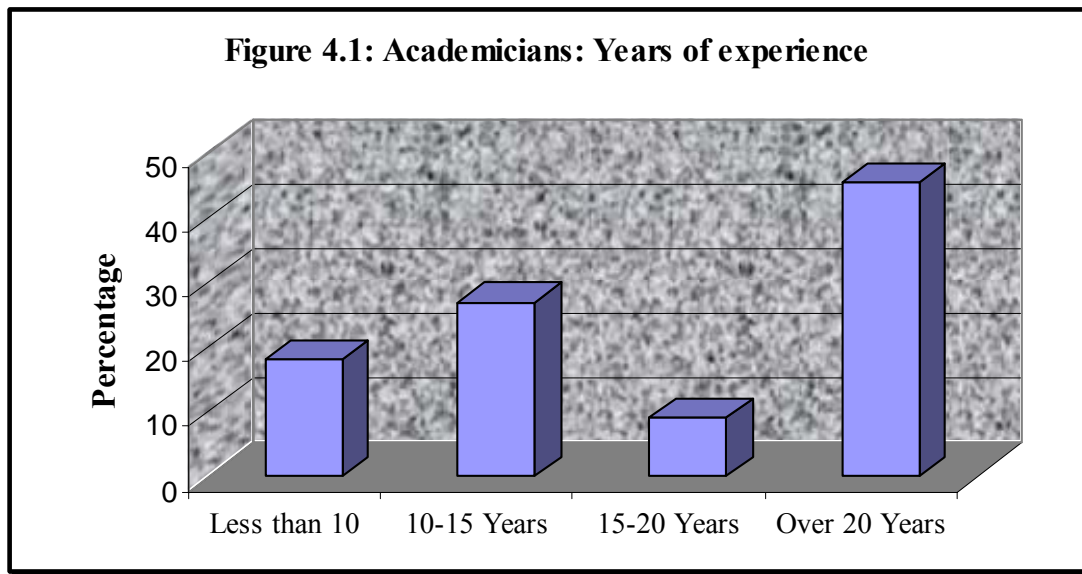


Figure 4.1: Academicians: Years of Experience

It was noticed from the survey, that the qualities of these immensely experienced and qualified academicians includes there dedication in particular domain. The area of specialization for substantial number of faculty members is Construction Engineering and Management, specifically areas of Project Management, Quality control, Productivity, Planning and Costing. Around 40 percent of the experts are directly related to Civil Engineering, specializing in Concrete durability, modeling of concrete structures, construction materials, and durability of structural materials.

Based on the educational and professional background, the teaching and research experience, the domains of specialization and their prestigious work place, it is strongly

validated to seek the professional reviews from the academia experts well-informed of activities related to the construction contractors. It is expected that the responses from academicians will provide the rationale for the contractor's organizational aspects.

4.2.2. Contractors

The participating contractors are highly experienced professionals from the construction industry. About fifty percent of the experts have more than 20 years of professional experience in construction business. The remaining contractor professionals have experience ranging between 10 to 20 years, as pictorially depicted in figure 4.2. These vastly experienced industry professionals occupy senior and highly ranked administrative positions within the firms. Two of the experts are ranked as General Manager, another three of them work as project manager, rest dedicates their services as Senior Manager, Operations Manager, Area Manager, QA/QC Supervisor.

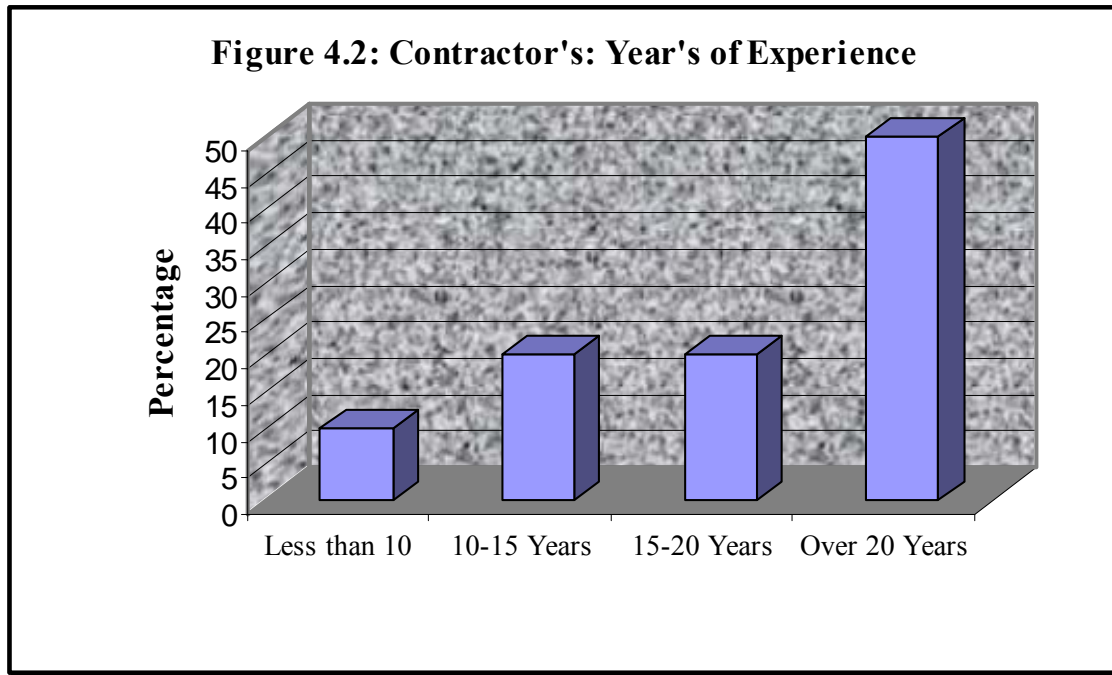


Figure 4.2: Contractor's: Years of Experience

The participants work for successful construction firms belonging to different categories. Five experts work in Grade-01 construction firms, two experts work in Grade-02 and the remaining three works in Grade-03 Construction Company. The views of contractors from firms of different grades were sought to get a more diversified & comprehensive review.

Along with possessing vast experience, most of the participating contractor professionals are associated with projects from more than one sector. This particular trait of the professionals advocates the fact that they are aware with the requirements of overall construction industry. Sizeable numbers of them are involved in Government Projects such as oil, gas, chemical, petrochemical & refinery, electro mechanical etc. Thirty

percent are in Semi-Government Projects and rest are involved in Private Projects. A particular coincidence recognized between the projects undertaken by the respondents was that, the projects these contractors associated with are mostly related to Saudi Aramco, SABIC and SEC.

It has also been discovered about the types of projects and works undertaken by the participating contractor professionals, that the majority of the experts are involved in multiple types of projects. Almost all the experts are engaged in industrial type of projects, followed by residential and commercial projects. This trend may be due to a rise in industrial construction undertaken in the kingdom over past decades, to get self-reliant in industry, and the commercial and residential construction undertaken to support this industrial growth.

Based on the professional work experience, administrative position, expertise in different domains of construction, and other noticeable traits it is justifiable to infer that construction industry professionals identified for this research have adequate knowledge of activities and functions associated with construction project management.

4.3. Model Description

Models are defined as the representation of complex situation, a model offer its users the means of comprehending an otherwise incomprehensible problem. As mentioned in research methodology, this thesis develops a model encircling the “Organizational

aspects of the Contractors, Project Management Elements”, the Cost, Time, Quality Control and Safety.

The overall model was developed in two stages, initially based on the extensive literature analysis a potential model was developed and then in the second stage it was refined by the qualified reviews of experts from the Academia and the industry professionals. This section describes the models for Cost estimation, Planning and Scheduling, Quality control and the safety departments.

4.3.1. Cost Estimation Department

Cost Estimation is one of the most important aspects for efficient functioning of a construction company. In this research Cost Estimation comprises one of the four departments, whose organizational aspects are benchmarked. Based on extensive literature review presented in chapter-II, the key organizational aspects of the contractors cost estimation department were identified, as depicted in the figure 4.3. These organizational aspects were further classified to shape a comprehensive model, each of which are explicitly illustrated below.

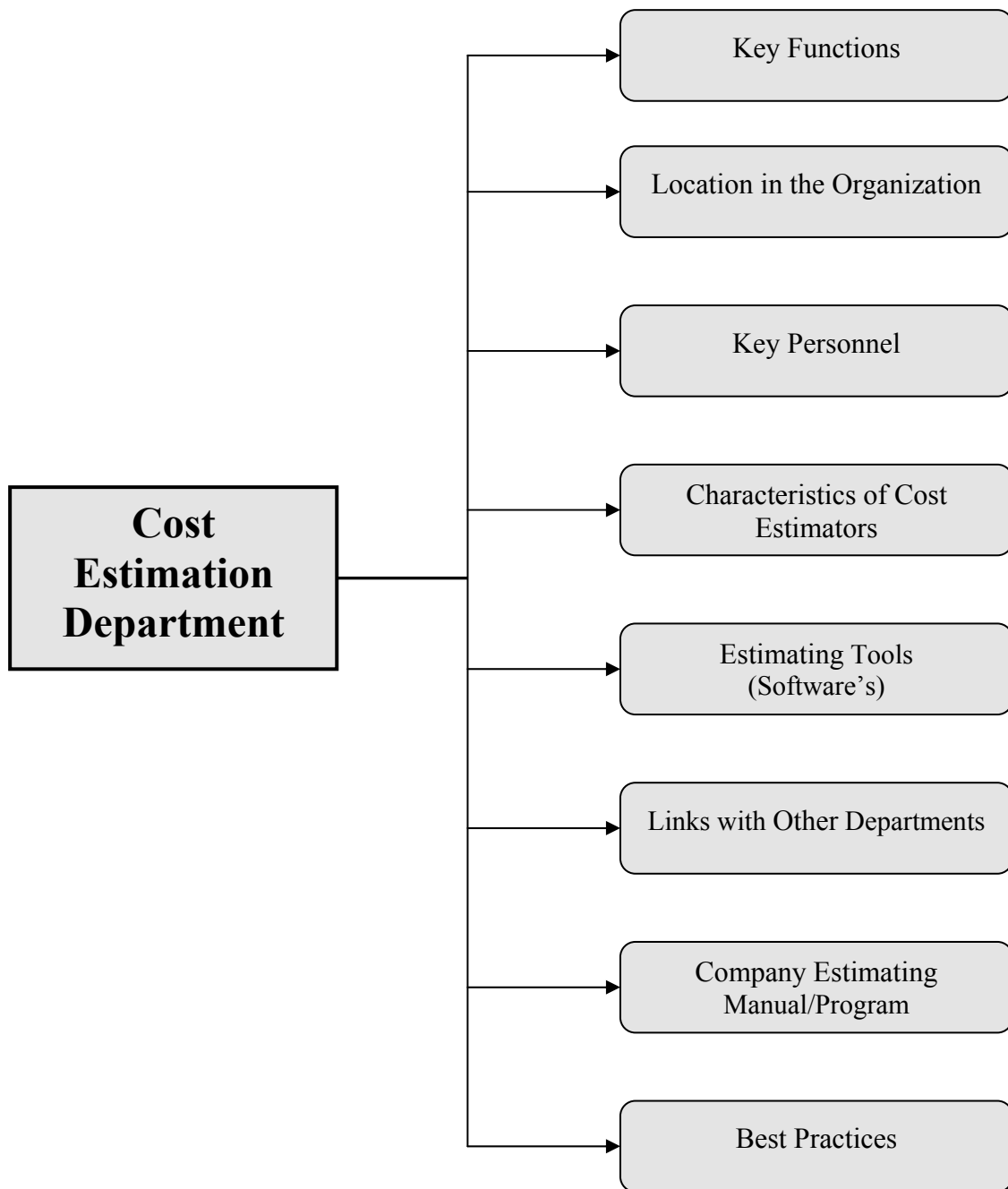


Figure 4.3: MODEL: Organizational Aspects of Cost Estimation Department

I. Key Functions

Functions are the actions and activities assigned to or expected of a group or organization. The key functions of the cost estimation department are the activities it is required to execute for generating competitive estimates and to make the contractor firm work efficiently and flourish in the construction industry. This section of the model identifies the key functions of contractors cost estimation department.

Expert's opinion on the key functions identified from literature analysis suggests that both the academicians and contractors have common understanding about the key functions of a cost estimating department. Almost all the experts strongly agreed on key functions including, "Determining the direct and indirect costs of the construction projects", "Generate quantity takeoff", and "Recommending projects to tender". These opinions suggest that the primary aim of the contractor out of cost estimation department is to identify the probable direct and indirect cost of the project on the basis of quantity takeoff. Based on these results it can be comprehended that the eventual aim of the cost estimation department is to tender an amount in response to invitation of bids. These functions are very important as the bid amount will determine the fortunes of the firm, and if the department quotes competitive amount they will hold high probability of engaging a project.

About the other functions, around seventy percent of the academicians and contractor professionals agreed that the key functions must also include functions like, "to prepare bids for submission", and "evaluate project estimator". This indicates that along

with determining the cost and recommending an appropriate project to tender, the estimation department also holds the responsibility to prepare bid documents for submission. These bid documents will give the contractor an opportunity to evaluate the efficiency of his project estimator. Small number of contractor professionals also recommended that one of the key functions should be to establish and discuss project execution cost. However majority of the academicians and contractors expressed that “scheduling of projects” and “control or monitoring of project execution” cannot be the key functions of cost estimation. These reviews suggest that the determination of overall cost and recommend projects to tender are the primary functions, and the secondary aims include the evaluations. But the control for project time and execution doesn’t come under the functions of estimating department, though they can be classified under some of the other outcomes.

II. Location in the Organization

Location of a department in the overall organization structure of the firm suggests its hierarchy of reporting and communication with the officials above and under its level. This particular organizational aspect of contractors cost estimation department identifies the most fitting location of the department in the entire firm.

The experts were asked to provide remarks on the best location of the cost estimation department in the contractor organization. The majority of both the Academicians and industry professionals articulated that, it is most appropriate for the

chief estimator to report directly to the Vice President of the organization, while the vice president will communicate the same to the Chief Executive Officer (CEO) when ever required. It seems that the experts considered it more realistic for cost estimation department to maintain direct links with the Vice president of the organization, instead of Chief executive as cost estimation is a multi-disciplinary function and it requires constant support from higher officials in the firm. Hence it is practical to be located under the backing of Vice President of the firm.

However a few number of contractor professional indicated that in large construction firms it is more appropriate for cost estimation department to be located directly under the CEO. They advocated their review by articulating that for small and medium size projects, it is the chief estimator and vice president who take the overall decisions, but for mammoth projects it is appropriate to include the CEO, as any erroneous decision concerning large projects will be risk taking. This theory suggest that though the most appropriate location is directly under VP, but when needed the Chief estimator should get in contact with the CEO.

From the potential model and experts vision it is comprehended that, in the hierarchy of reporting for Cost Estimation department, the CEO will occupy the level-I in the ranking, followed by the Vice President at the level-II and the Cost estimation department at the level-III in the hierarchy. The estimating staff, Quantity surveyors, and site management, who forms the key personnel's in cost estimating will report to the chief

estimator. Figure 4.4 depicts the pictorial representation of the best location of the cost estimation department in the hierarchy of contractor organization.

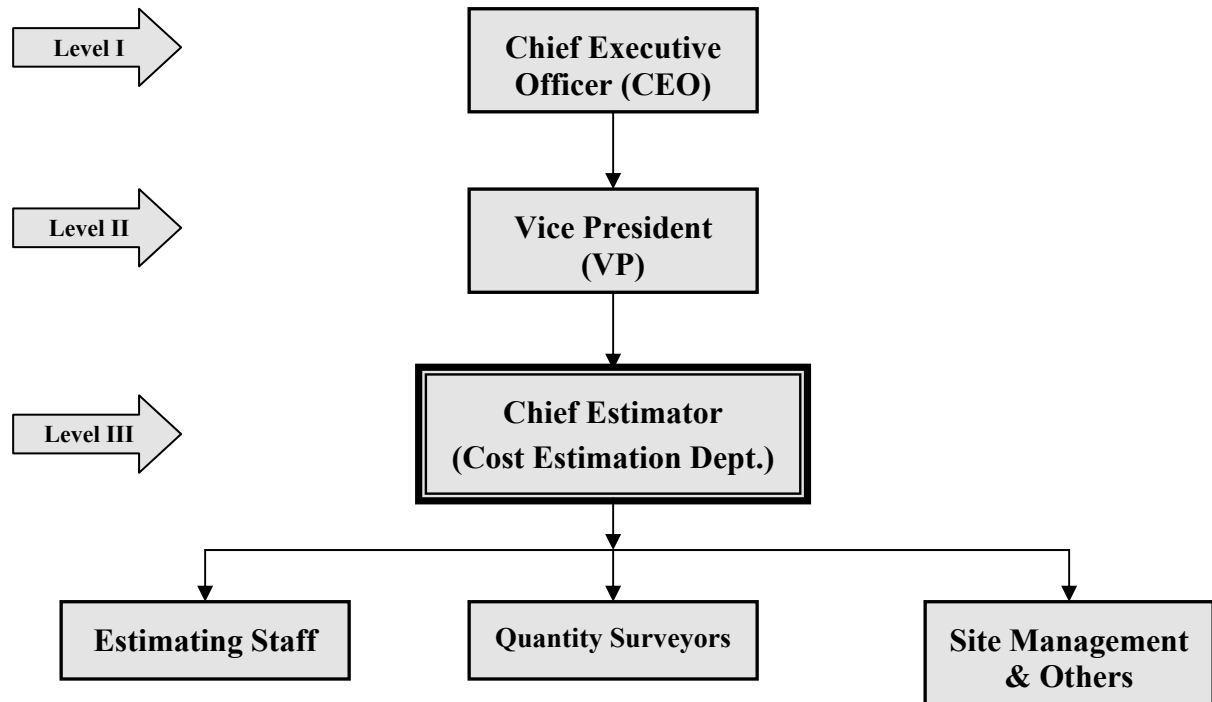


Figure 4.4: Best Location of Cost Estimation Department

III. Key Personnel

This organizational aspect of cost estimation department identifies the personnel jointly liable for generating a competitive cost estimates. Potential model on organizational aspects of contractors cost estimation department suggest that the key personnel's responsible for generating cost estimates include the Chief estimator, Estimating staff, Site management, Quantity surveyors & others. This fact is strongly advocated by the

expert's opinion, all the participating Academicians and the Contractors professionals agreed or strongly agreed that cost estimation department is headed by chief estimator and the quantity surveyors as the key personnel. These opinions rightly designate the Chief estimator with overall responsibility of the department. The reviews also suggest that quantity surveyors play an important role in the department. Further around eighty percent of the academicians and industry professionals advocated for estimating staff and Site management.

The experts review apparently supports the fact that Chief estimator develops the estimates based on the quantity estimates from the surveyors, who are assisted by the estimating staff and the site management.

Fifty percent of the contractor professionals suggested that construction manager is also a part of cost estimation crew. However 70 percent of the academicians shared contrasting view and they disagreed on considering construction manager as key personnel in cost estimation department. It seems that contradicting views of contractor and academic experts went with the fact that construction manager takes care of construction execution process which happen after bidding stage, hence based on the experts opinion it can be concluded that construction manager is not among the key personnel of cost estimation department.

Among the noteworthy comments given by the interviewed experts include that, for generating competitive cost estimate, lower ranked personnel like estimating staff, site management and others play a major role and hence a proficient contractor should

incorporate and appraise these personnel. They further mentioned that successes of cost estimation department depends on contribution from all the personnel.

IV. Traits of Cost Estimators

Highly knowledgeable personnel with broad set of both technical and nontechnical skills are prime need of every efficient estimating organization (Dysert L, Bruce G, 2000). It is comprehended from the above section that the Chief estimator is one of the key personnel in cost estimation department. This organizational aspect recognizes the important traits of this individual.

Opinions from the experts including academicians and the contractors suggest that, a well qualified estimator is requisite for developing a good estimate. Around ninety percent of the participants agreed or strongly agreed that cost estimators should have following traits including, Knowledge of construction methods, Knowledge of Material costs, Mathematical Skills, Current knowledge of latest construction trends, Knowledge of cost details, Software skills, Knowledge of competitive environment and general economics. These results strongly suggest that a well qualified estimator is essential for generating competitive cost estimates. Knowledge of construction methods and material costs are very essential for estimator to price the over all work activity, where as current information of construction trends along with the proficient software skills helps the estimator to generate accurate estimates with presentable reports. One contractor adduced that general awareness of economics plays an important role in case specific points such

as Euro exchange rate, price variation of steel, copper cables, and other materials, taxes and duties etc.

Some expert contractors suggested that along with the aforementioned skills the cost estimators should also keep knowledge of engineering design, as cost estimates vary with complexity of engineering design. However about having communication skills as the important trait for cost estimators, 80 percent of the academicians and 30 percent of the contractors either remained neutral or disagreed with the same. This review of experts seem to indicate that based on the accurate work quantities and numbers a good cost estimate can be developed without much need of communication. Based on the overall responses it can be comprehend that a qualified and experienced estimator is necessary for developing a good cost estimate.

V. Estimating Tools (Software's)

Employing latest tools is one of the important organizational aspects of Cost estimation department. Almost all the experts unanimously confirmed that use of latest estimating tools are essential for generating accurate and detailed estimates. However when queried about the particular estimating software to be employed, diverse responses were received. 50 percent of the academicians and 80 percent of the contractors articulated that Timberline software or any other suitable software is necessary for large contracting firms. Some experts also named software's like WinEstimator, Success Estimator, ArchiCAD as good estimating tools. This discrepancy in opinions seems to be

because of the fact that multiple software brands exist in the market and also the contractors select a particular software depending on their convenience.

However, experts who are part of Grade-III contractors and 50 percent of the academicians either remained neutral or were not really sure about the software's to be employed. Contractor experts from aforementioned grade expressed that the firms of miniature size never feels the necessity for estimating software, hence normally they prefer the manual methods, but they added that estimating tools will definitely help in generating accurate estimate. This practice seems to be directly proportional to the size of the firm and hence, the size of the projects. Whereas the academicians expressed their unawareness about the latest estimating software's in the construction market and hence remained neutral, this feedback of faculty members clearly implies that the software tools for cost estimation are recently introduced and also because the faculty members are not well aware of the same.

The abovementioned responses and other remarks by the experts suggested that software technology, though employed by many estimators but still remains new for the rest. The tendency to use estimating software's by large contractor firms is justified by the fact that large projects constitute mammoth investments and any underestimation or overestimation of project cost could seriously affect the company's future.

VI. Links with other Departments

For preparing realistic estimates, the cost estimation department should have good communication and strong links with other departments in contractor firm. Almost all the experts expressed that there should be strong links between Cost Estimation and Planning & Scheduling departments, they cited that there is direct relation between cost and schedule, a fast track project cost more than a regular project. Further it is important for scheduling department to price for the multiple resources mainly falling in critical path such as major equipments, key personnel, transport logistics such as freight by air/sea and similar cost sensitive aspects to bid, therefore links with schedule department is essential. These results strongly advocates for strong links between cost estimation and planning & scheduling counterparts.

Further eighty percent of the contractor professionals and 75 percent of academicians strongly advocated upon having strong links of cost estimation department with Quality Control and Construction Safety departments. The experts review indicate the fact that cost and quality are interdependent, and to achieve high quality edifice along with the improved techniques better-quality material and labor has to be employed which results in increase cost. Hence the cost estimation department needs to be in contact with quality control department to know the specifications. Similarly higher safety concerns end up increasing the overall budget of the project or contrariwise, which demands the need for good links between cost estimation and safety counterparts.

Along with the aforementioned, majority of both the contractors and academicians suggested that cost estimation department should also have positive relations with

Procurement/Purchasing department and Finance departments. This is expressed by the fact that the Procurement department provides the estimators with the price bank of the raw materials and other essentials.

VII. Company Estimating Manual/Program

An Estimating Manual/Program is a set of procedures for setting the framework for Cost estimation. It is one of the important organizational aspects of contractor cost estimation department. This section identifies the key components necessary to be illustrated in a company estimating manual.

The contractor should develop his written “Estimating Manual”, which should describe the working system, estimating techniques and other details of his firm. As these manuals serve as a source to provide company cost estimators with a dependable, proven basis for obtaining production efficiency percentages by applying all known local conditions and variables. This information is also comprehended from the responses of experts, almost all the participants including the academicians and the industry professionals either agreed or strongly agreed about the fact that every contractor irrespective of size, and experience should develop his Estimating Manual/Program which shall present, Overview of the estimating process, Review of estimate requirements, Planning the estimate, Structuring the estimate, developing the estimate, documenting the basis of an estimate, and estimate reporting. The reviews of academic and contractor professionals suggested that maintaining written estimating manual/program is very

essential as it is considered to be a very effective means of communication within the department and overall organization. Whereas documenting the basis of an estimate and the estimate reporting helps to keep a return record for current review and as a reference for future projects. Some of the experts voiced that a Price bank, detailing the current prices of material, labor and others should also be the part of company estimating manual. An updated price bank will assist the estimator in pricing the materials, labor and other items without referring to the other sources.

Among the additional comments of the industry professionals include that, as the size of a company increases, the need for a written estimating manual increases, although it is necessary irrespective of the size of the firm. The expert contractors also cited an encouraging fact that the major mammoth firms in the Saudi Arabia do maintain their own Estimating Manual.

VIII. Cost Estimation: Best Practices

Along with the various organizational aspects which facilitate the contractors cost estimation department to function efficiently, there are some paramount practices which are considered beneficial, were also part of potential model. This section enlists some of the best practice recommended for cost estimation department.

Almost all the academicians and industry professionals reckoned that cost estimation should be performed prior to the bidding stage. This opinion implies that cost estimation is one of the first activities to be initiated in a project. The successes and failure

of the contractor to receive the contract depends on the competitiveness of the estimates. However the experts also articulated that the cost estimation process is usually initiated after the management decides to bid for the project.

Further, eighty five percent of the experts jointly mentioned the following practices very important or extremely important for forming a benchmark cost estimating department, maintaining a well compiled “Estimating Manual”, training for each estimator, maintaining “Employee development plan”, Up-to-date Estimating tools, Cost estimation department should have effective communication process with relevant Project Management personnel. These reviews of the experts further reinforce the model which strongly advocated for Estimating Manual, employing the latest estimating software and tools. Expert’s recommendation for training of estimators suggests that a trained estimator will required knowledge and skills necessary for generating competitive estimates. Training also helps the estimator to get acquainted with the company policies.

Among the other recommended practices of estimating department include, seniors from estimating department and construction department must visit the proposed project site to evaluate site conditions prior to preparation of estimate. This practice seems to recommend that the site management of estimation department should assess the project site conditions before developing the final estimate. The practices also include maintaining clear strategy about which project to bid, this particular best practice suggest that the estimating department should have explicit plan to scrutinize the appropriate projects depending upon the size, budget, duration and other strategic details. The experts

also recommended that, to lower the company overheads estimating group should be minimum and professional. This practice recommends that fact that estimating staff should be less, but qualified enough to develop competitive estimates.

Summary of Cost Estimation Department

The figure 4.1 presents the summary of the organizational aspects essential for the efficient functioning of the contractors cost estimation department.

TABLE 4.1: Organizational Aspects of Cost Estimation Department

ORGANIZATIONAL ASPECTS OF COST ESTIMATION DEPARTMENT		
Key Functions	Location in the Organization	Key Personnel
<ul style="list-style-type: none"> • Determine the direct and indirect cost of the construction Project 	First Level of the Hierarchy: CEO	<ul style="list-style-type: none"> • Chief Estimator
<ul style="list-style-type: none"> • Generate Quantity Takeoff 	Second Level of the Hierarchy: Vice President	<ul style="list-style-type: none"> • Estimating Staff
<ul style="list-style-type: none"> • Evaluate Project Estimator 	Third Level of the Hierarchy: Chief Estimator	<ul style="list-style-type: none"> • Site Management
<ul style="list-style-type: none"> • Prepare bids for submission • Recommend projects to tender 		<ul style="list-style-type: none"> • Quantity Surveyors
Traits of Cost Estimators	Estimating Tools (Software's)	Links with Other Departments
<ul style="list-style-type: none"> • Knowledge of Construction Methods 	<ul style="list-style-type: none"> • Timberline Software 	<ul style="list-style-type: none"> • Planning & Scheduling
<ul style="list-style-type: none"> • Knowledge of Material cost 	<ul style="list-style-type: none"> • WinEstimator 	<ul style="list-style-type: none"> • Procurement Department
<ul style="list-style-type: none"> • Mathematical Skills 	<ul style="list-style-type: none"> • ArchiCAD 	<ul style="list-style-type: none"> • Finance/Accounting
<ul style="list-style-type: none"> • Current Knowledge of Construction Trends 	<ul style="list-style-type: none"> • Success Estimator 	<ul style="list-style-type: none"> • Quality Control
<ul style="list-style-type: none"> • Knowledge of Cost details 	<ul style="list-style-type: none"> • Other Suitable Software's 	<ul style="list-style-type: none"> • Construction Safety
<ul style="list-style-type: none"> • Software Skills 		
<ul style="list-style-type: none"> • Knowledge of engineering design 		
<ul style="list-style-type: none"> • Knowledge of competitive Environment 		
Key Contents of Estimating Manual	Cost Estimating: Best Practices	
<ul style="list-style-type: none"> • Overview of the Estimating Process 	<ul style="list-style-type: none"> • Construction Cost Estimation should be performed prior to the bidding stage 	
<ul style="list-style-type: none"> • Review of estimate requirements 	<ul style="list-style-type: none"> • A contractor with multiple number of estimators and division, should maintain an "Estimating Manual" 	
<ul style="list-style-type: none"> • Planning the estimate 	<ul style="list-style-type: none"> • Extensive training should be conducted for each Estimator 	
<ul style="list-style-type: none"> • Structuring the estimate 	<ul style="list-style-type: none"> • Training for each individual estimator is expected to be summarized in "Employee Development Plan" 	
<ul style="list-style-type: none"> • Developing the estimate 	<ul style="list-style-type: none"> • Estimating tools must be kept up-to-date for maximum effectiveness 	
<ul style="list-style-type: none"> • Estimate reporting 	<ul style="list-style-type: none"> • A proficient contractor should have effective communication with relevant project management personnel 	
<ul style="list-style-type: none"> • Price Bank (Cost database) 	<ul style="list-style-type: none"> • Seniors from estimating department must visit the proposed project site to evaluate site conditions prior to preparation of estimate 	

4.3.2. Planning & Scheduling Department

Planning & Scheduling is the core for successful project management, it grants the innermost communication that coordinates the work of all parties. In this research Planning and scheduling comprises one of the four departments, whose organizational aspects have been benchmarked. Based on extensive literature analysis presented in Chapter-II of this research, the key organizational aspects of the contractors Planning & Scheduling department were identified, figure 4.5, clearly depicts the key organizational aspects. These organizational aspects were further classified to shape a comprehensive model, each of the which are explicitly illustrated in following sections.

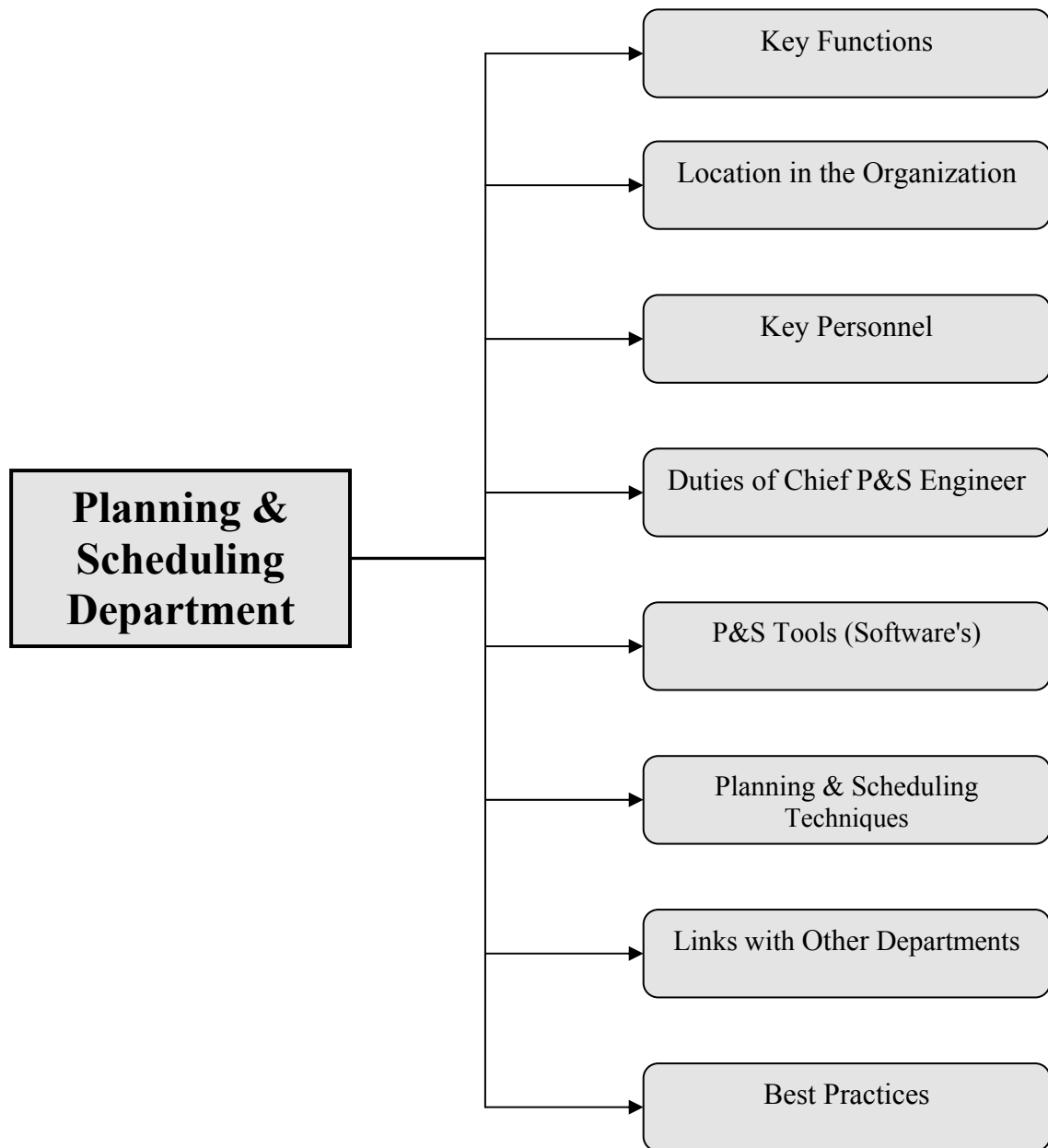


Figure 4.5: MODEL: Organizational Aspects of Planning & Scheduling Department

I. Key Functions

Key functions of the contractors Planning & Scheduling department are the core objectives it is required to execute, to help the contractor firm work efficiently and prosper in the competitive industry. This section of the model scrupulously identifies the key functions of P & S department.

Expert's opinion on the key functions acquired via questionnaire suggests that Planning & Scheduling is an important element of contractor and hence constitutes many objectives. Seeking opinion about the key functions revealed that, both the academicians and contractors shared the common ideas. Almost all the expert's agreed or strongly agreed on following functions including, "ensuring completion of projects on time", and "ensuring continuous and incessant flow of work without delays". Respondents view on these functions clearly suggest that time is most important parameter for the planning and scheduling department, to complete the project on time the flow of the work has to be continuous and without obstructions. Hence it can be viewed that planning and scheduling department should plan and schedule its activities and resources systematically enough to finish the project within the specified time.

Among the other major functions, almost ninety percent of the academicians and industry professionals ranked, "Limiting the confusions and misapprehension in the schedule", "meaningful and timely reports to management", "acquaintance with the scheduled times of key parts of the project", "accountability of the individuals, their responsibilities and powers" as the key functions. The results evidently suggested that the

objective of planning & scheduling department is to coordinate the entire project systematically enough to avoid confusions and delays due to delusions. It is comprehended that one of the duties of P&S department is to assign individual attention to important activities at essential times. The key functions also indicate that every individual related to the project must be assigned due task to level the resources.

Further, 80 percent of the participants agreed that the key functions must also comprise, “Keeping an updated record of all project progress”, “Clear comprehension of who does what, when and how much”, and “Integration of entire work to make sure a quality project for the owner”. Maintaining the record of project progress helps the contractor to evaluate the progress at every stage and if the project is behind schedule activities can be rescheduled to fasten the work. The expert opinion also suggested that one the function of the P&S department is to keep track of every personnel involved in project.

The contractor expert’s also stressed on some functions outside potential model including, “Developing and updating the project plan”, “Resource leveling for better project management” and “Proper sequencing for maximizing profits”. Resource leveling is rightly regarded a key function, as it insures the uniform distribution of all the resource over the entire project.

II. Location in the Organization

Location of a department in the overall organization structure of the firm suggests its hierarchy of reporting and communication with the officials above and under its level. This section presents the most fitting location of the Planning & Scheduling department in the hierarchy of the firm.

Planning & scheduling department is headed by the chief planning & Scheduling engineer; he is assisted by the project scheduler, scheduling assistants and project manager to schedule the entire project. The experts were asked to provide remarks on the best location of the Planning & Scheduling department in the contractor organization. Majority of the industry professionals and academicians articulated that, it is most appropriate for Chief P&S Engineer to report directly to the Vice President of the organization, While the Vice President will communicate the same to the Chief Executive Officer when ever necessary. The opinion seems to be on the basis that planning and scheduling is a multi-disciplinary function and it requires repeated exchange of information and assistance from higher authorities and hence the direct links with vice president is more practical. Where as, the Chief executive officer may not be acquainted with the all the miniature details related to planning & scheduling function. There fore it is more appropriate for P&S department to be located directly under the vice president of the firm.

From the potential model and experts vision it is comprehended that, in the hierarchy of reporting for P&S department, the CEO will occupy the level-I, followed by the Vice President at the level-II of the hierarchy and the P&S department at the level-III of the hierarchical ladder. Project scheduler, Scheduling assistants, Project manager and other personnel's will work under the Chief P&S Engineer. Figure 4.6 illustrates the pictorial representation of the best location of the Planning and Scheduling department in a contractor organization.

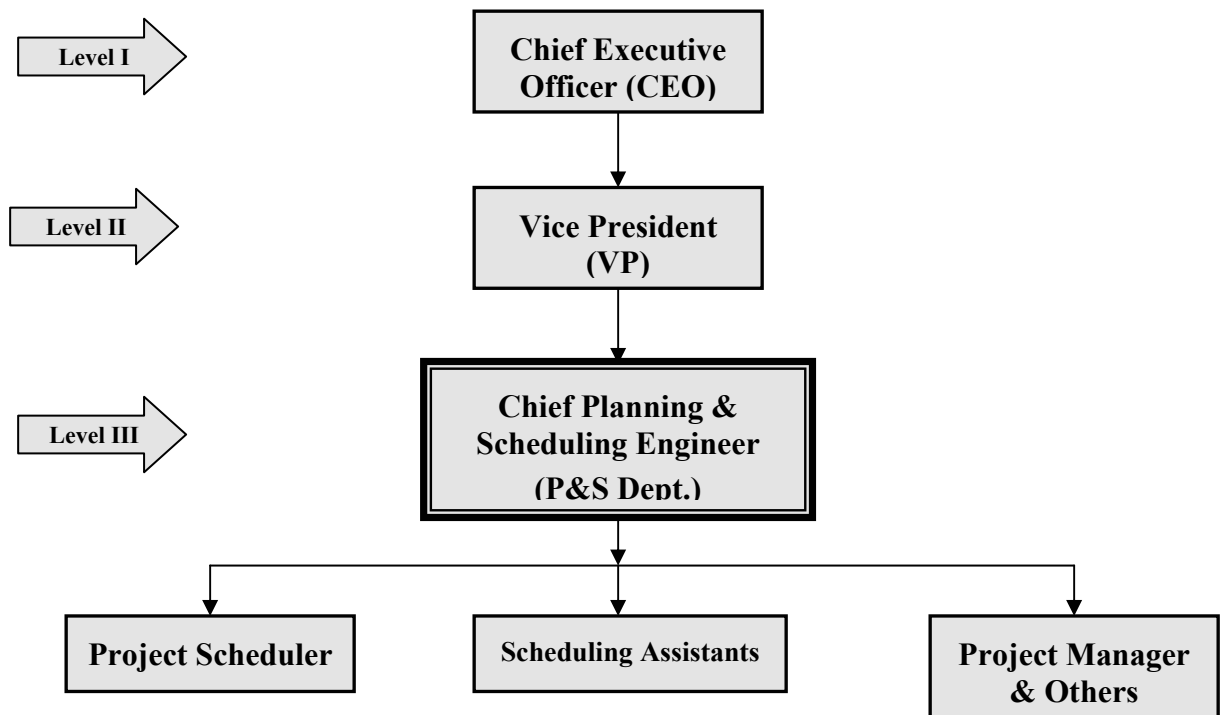


Figure 4.6: Best Location of P&S Department

III. Key Personnel

This section of the model identifies the key personnel, who should be part of planning & scheduling crew. Contractor's and Academicians opinion on key personnel responsible for Planning & Scheduling of the various projects suggest that, Chief Planning & Scheduling Engineer is the main personnel of the department. This opinion is in concurrence with the potential model developed based on the previous researches, which suggest that chief P&S engineer schedules the entire project with assistance from schedulers and other personnel.

Around ninety percent of the contractor professionals and academicians mentioned that Project scheduler and Scheduling assistants are also essential members for planning & scheduling of the entire project. This suggest that ground work for overall scheduling is taken care by the scheduling assistants and the project schedulers, where as the chief P&S engineer is responsible for developing final schedule. In addition to the aforementioned personnel, the expert's also articulated for Project Manager, and the Field Engineers as the substantial contributors in Planning and Scheduling, during the project execution stages.

Among the prominent comments given by the interviewed experts include, that the size of the firm and the projects also plays a key role in deciding the key personnel. A large project obviously requires more number of personnel compared to a miniature one. However the key personnel are essential in every project. Suggestions from experts also

include that, the low ranked personnel including Scheduling assistants, schedulers and other subordinates play a key role in overall output and hence they should be appraised.

IV. Duties of Chief P&S Engineer

This research has already revealed that contractors Planning & Scheduling department is headed by Chief Planning & Scheduling Engineer. Chief P&S engineer is liable for taking care of many activities to make a practical schedule. This organizational aspect of the model recognizes the important duties of the chief P&S engineer. Almost all the respondent agreed or strongly agreed that foremost job of the chief engineer is to Plan and Schedule the entire project.

The other important tasks expected are the “Progress monitoring”, “preparing project planning and scheduling related procedures and guidelines”, and the “Management coordination”. Progress monitoring is an important task and it deals with assessing actual progress with the preplanned progress. If there are any modifications, it is the responsibility of the Chief engineer to communicate the same to all the team members. Hence progress monitoring is comprehended as the important duty. Whereas the management coordination must have been ranked as important duty as it promotes coordination with in the entire project team.

V. Planning & Scheduling Tools (Software's)

This section of the model distinguishes the tools and software's that helps to make Planning & scheduling task more precise. Academic and industry professional's opinion concerning the Planning & Scheduling tools was very encouraging, almost all the experts confirmed that, the use of latest tools and software's are essential for Planning & Scheduling of large projects with hundreds and thousands of activities. However they also strongly recommended that even for small firms and their miniature projects, software's are effective in generating accurate and detailed schedules.

Almost all the contractor professionals and eighty percent of the academicians suggested that Primavera Project Planner P3, Microsoft Project or other suitable software should be employed for quality work. These responses suggested that it is highly recommended to employ any of the aforementioned software tools to plan and schedule the entire project however it is evident from the response ratings that Primavera Project Planner P3 is the most preferred tool among the rest. The disparity in the response rating of the two expert groups seems to be because, some of the academicians expressed there lack of knowledge about the latest tools in the market. Some of the industry professionals also named Primavera Suretrak as a good tool, hence further adding to the list of tools.

Though the afore mentioned results suggest that IT technology is widely employed in Planning & Scheduling of construction projects, however some of the industry professionals expressed that, a few Grade-III type of contractor firms are still

unacquainted about these tools. This tendency of small firms suggests that contractors with miniature projects doest feel worth to employ the costly but accurate tools. However the overall responses and other remarks from the experts suggested that software technology is very essential in current day construction industry, but it still needs promotion in Saudi Arabian construction industry.

VI. Planning and Scheduling Techniques

One of the techniques for performing in competitive construction industry is to improve planning, scheduling and analysis of construction operations. Many planning & scheduling techniques have been mentioned in the literature analysis of this research. The opinion of academicians and industry professionals suggested that critical path method (CPM) is the best technique and should be employed by the contractors to survive the competitive industry. The responses indicate that most of the professionals are content with the critical path method. These results are comprehended with the fact that CPM is very much useful for the large and medium size contractors to improve planning before commencement of work, a detailed planning is the usual outcome. In Critical Path Method technique, the activities are represented by an arrow and its events are represented by circles. It is also a very good tool at project management level, it provides improved project control during the project execution stages. Hence it can be suggested that CPM is the technique to excel for contractors.

Among the other major techniques, Seventy percent of the expert respondents ranked, Program evaluation & Review Technique (PERT) as it helps to manage uncertainties in activity completion times. However some experts either remained neutral or disagreed with the same. This seems to be result of the fact that PERT is complicated technique and it creates difficulty for project engineers and planners to accurately estimate the optimistic and pessimistic durations. Further seventy five percent of the respondents agreed with adhering to Gantt Bar Chart technique, although it is the most conventional. This must be because of its simplicity, its ease of amendment and above all its user-friendly interface.

Large number of experts disagreed or remained neutral on Graphical Analysis & Review Technique (GERT) as a technique to excel, as it is outdated. 50 percent of the academicians and industry professionals remained neutral on Precedence Network Diagram, this is because of its minimal use in industry and also as some academicians expressed that it is alike of CPM. Among the other techniques, interestingly some academicians backed Line of Balance (LOB) and its variations as a good Planning & Scheduling technique. This must be because of its application in repetitive type of projects where similar activities are repeated.

VII. Links with other Departments

For proficient functioning, Planning & Scheduling Department should have beneficial links with other departments in contractor firm. The relation with other counterparts helps in synchronizing with the other elements of construction. Ninety five percent of the responses indicate that there should be good links of P&S department with Cost Estimation counterpart. This is strengthened by the fact that cost and time are interdependent and any deviation in one of them will influence the other. It is a common experience in construction industry that any project behind and ahead of schedule will substantially increase the overall expenditure and hence by maintaining good communication with each other, things can be kept under control.

The professional's responses also advocated for links between P&S department with Quality Control and Construction Safety counterparts. This opinion must be based on the safety records from the project sites which suggest that projects with frequently updated schedules have better safety performance than the contrariwise, as it allows the work force to foresee the areas of possible conflicts. Hence it is necessary to maintain links with safety counterparts. Whereas as quality and time are also correlated, therefore relations within these departments are necessary.

Many of the participating academicians and contractor professionals also advocated for strong relations with Purchase/Procurement, Project Execution & Operations department. This review suggest that purchase department acquaint the schedule

counterpart about the availability of the material, labor and other resources which guides the schedulers to assign the start and finish dates to an activity, hence the link between these two is essential. Where as relation with project execution and operations department is supported by the fact that execution & operations work are interdependent on schedule.

VIII. Planning & Scheduling: Best Practices

Along with the various organizational aspects which facilitate the contractor organization to function efficiently, there are some principal practices which are considered advantageous, this section of the model presents some of the recommended practices for Planning & Scheduling department. Ninety percent of the experts ranked the practice of “Planning & Scheduling should start at the project conceptual stage” as extremely or very important for the overall successes of the firm. This opinion of the experts suggests that P&S of the entire project should be one of the first tasks to be carried out. The primary advantage of early planning and scheduling is to establish the overall financial requirements in advance, this will happen in coordination with cost estimation department and hence also result in maintaining consistent cost estimates. Moreover any change in the schedule can be instantly responded if planning & scheduling begins at the project conceptual stage.

Among the other prominent practices, almost all the industry professionals and the academicians advocated, “Routine updating and monitoring of schedules” as extremely important practice, for timely & safe conclusion of projects. This is supported by the

discussion presented in previous sections that routine updating of schedules improves the safety performance of the contractor.

The respondents also expressed, “Eloquent internal communication between all the individuals participating” and “Documented report of daily activities to support schedules” among the best practices to enhance the performance of the Planning & Scheduling department. The expert opinion suggest that documenting the records of daily activities assists in evaluation of future activities and also it serves as historical data for other projects.

Summary of Planning & Scheduling Department

The figure 4.2 presents the summary of the organizational aspects essential for the efficient functioning of the contractors planning & scheduling department.

TABLE 4.2: Organizational Aspects of P&S Department

ORGANIZATIONAL ASPECTS OF PLANNING & SCHEDULING DEPARTMENT		
Key Functions		Location in the Organization
• Ensuring the Completion of projects as scheduled	• Integration of entire work to get quality project	• First Level of the Hierarchy: CEO
• Ensuring the Continuous and unremitting flow of work	• Accountability of the individuals, their responsibilities and powers	• Second Level of the Hierarchy: Vice President
• Limiting the confusions and misapprehension in the schedule	• Developing and updating the project plan	• Third Level of the Hierarchy: Chief Planning & Scheduling Engineer
• Keeping an updated record of all project progress	• Proper sequencing for maximizing profits	
• Providing meaningful and timely reports to management	• Resource leveling for better project management	
• Clear comprehension of who does what, when and how much	• Acquaintance of the schedule times of key parts of the project	
Duties of Chief Planning and Scheduling Engineer	Key Personnel	Planning and Scheduling Tools (Software's)
• Prepare project P&S related procedures and guidelines	• Chief Planning and Scheduling Engineer	• Primavera Project Planner P3
• Plan and Schedule the project	• Project Scheduler	• Microsoft Project
• Progress Monitoring	• Scheduling Assistants	• Primavera Suretrak
• Establish high technical expertise with everyone through continuous education	• Project Manager	• Other Suitable Software's
• Management Coordination	• Field Engineers	
P&S Techniques	Cost Estimating: Best Practices	
• Critical Path Method (CPM)	• Planning & Scheduling should start at the project conceptual stage, for:-	
• Project Evaluation & Review Technique (PERT)	a) Maintaining accurate and Consistent Cost Estimates	
• Gantt Bar Chart	b) Instant Evaluation of Changes	
• LOB & its variations	c) Establishing Metrics	
Links with Other Departments	d) Utilizing Historical Data	
• Cost Estimation	e) Training newcomers	
• Procurement/Purchase	• Routine Updating and monitoring of schedules, for timely and safe conclusion of projects	
• Construction Safety	• Eloquent internal communication between all the individuals participating	
• Quality Control	• Maintain documented report of daily activities to support schedule	
• Project execution & Operations		

4.3.3. Quality Control Department

Construction quality control is the performance of tasks which ensure the constructed facility is in accordance with plans, specifications, on time, and within a defined budget. This section presents the benchmark organizational aspects of contractors “Quality Control” department. Figure 4.7, clearly depicts the key organizational aspects of contractor Quality control department. These organizational aspects were developed based on the extensive literature analysis presented in chapter-II of this study, the following sub sections reinforce the potential model based on the reviews of industry professionals and academicians.

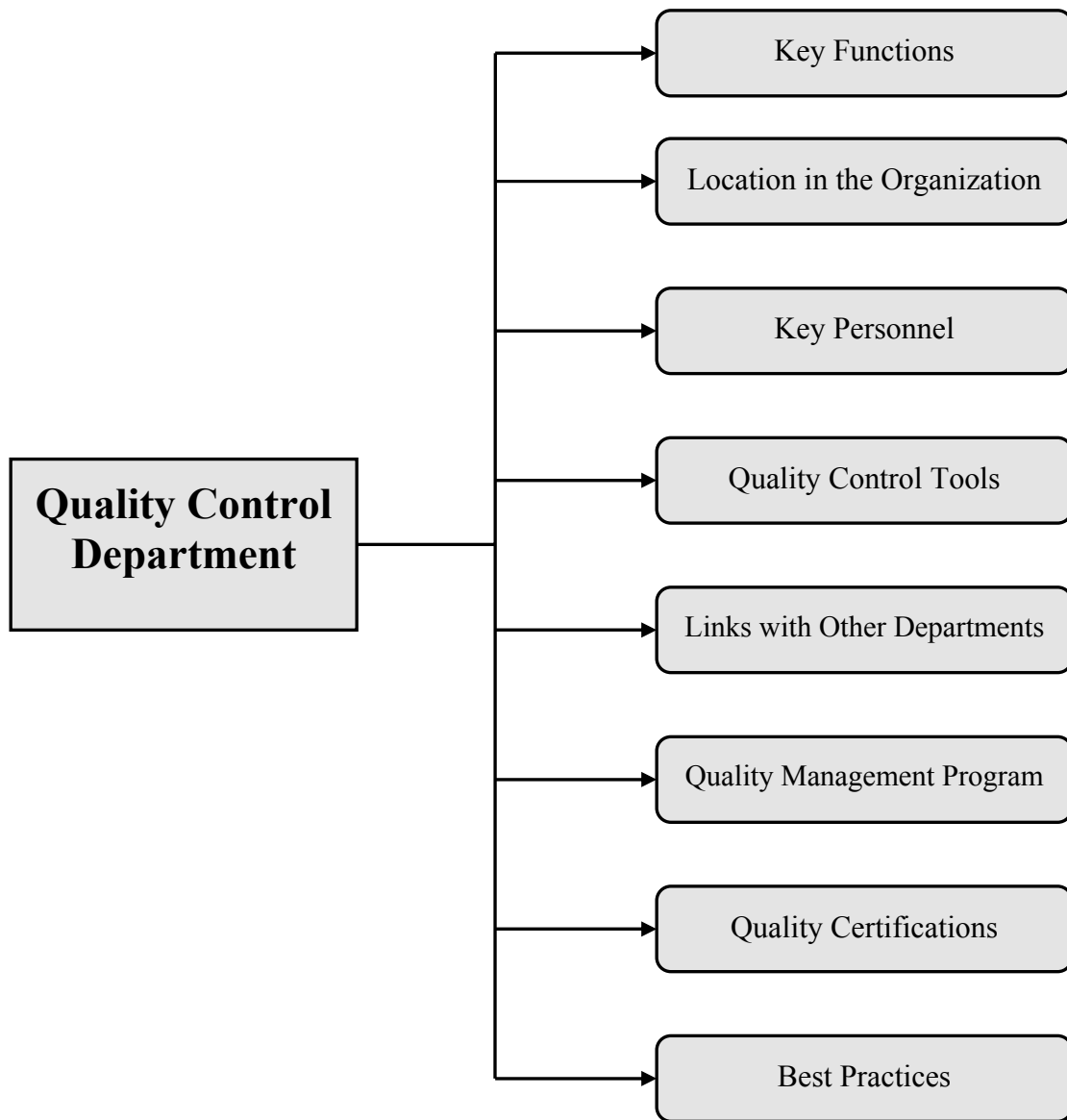


Figure 4.7: MODEL: Organizational Aspects of Quality Control Department

I. Key Functions

Functions are the actions and activities assigned to or expected of a person or group.

This section of the model identifies the important functions expected of a quality control

department. These functions determine the aims and objectives of the department while keeping the edifice in conformance to the requirements.

Academicians and contractor professionals opinion about the most fitting key functions of the quality control department suggests that both the academicians and contractors share the identical understanding about the same, 90-95 percent of the experts advocated for, “Assuring conformance to specifications”, “Providing competitive edge in the industry”, “Improvement of procedures” as the prominent functions. These reviews give a clear impression that attaining the expectations of the client is of foremost importance to the quality control department. This is comprehended from the client’s point of view, as they will be concerned with quality in terms of the application of the edifice to his or her particular use. Where as the contractor’s consistency to meet the client expectations provide a competitive edge in the industry. The expert’s opinion is also confirmed by an observation of the industry that the contractors practicing quality management programs have more chances of winning a bid. This suggests that quality control improves the system of the organization and eventually provides a distinction over the competitors.

Further, around eighty percent of the participants agreed or strongly agreed on, “minimizing rework”, and “minimizing the errors in the constructed facility”, as the key functions of the Quality control department. The result seems to be on the basis that errors during execution and the subsequent rework is one of the major causes of cost overruns

for the contractors. Therefore minimizing the errors and rework should be one of the important functions of the department.

However the 60 percent of the experts, particularly the academicians disagreed or remain neutral on considering “To complete project within budget and on schedule” as one of the key functions. It seems that the academicians consider time and cost as the specific responsibility of the cost estimation and scheduling counterparts, so it cannot be considered as one of the key functions.

Some of the industry professionals recommended for “Certification of personnel such as suppliers, permit receivers, equipment operators etc” as one of the objectives of the contractors Quality control department. Certification ensures quality material and manpower, which are essential to maintain quality edifice.

II. Location in the Organization

This section presents the most fitting location of quality control department in the overall organization structure of the contractor firm. Majority of the Academicians and industry professionals adduced that, it is most fitting for the quality control managers to report directly to the Vice President of the organization. This must be because of the fact that quality control is a multi-dimensional aspect and hence it's more practical for quality

manager to continually deal with vice president. Whereas the Vice President of the firm will communicate the quality aspects to the Chief Executive Officer when ever required.

However a small number of professionals believed that it is appropriate for Quality manager to be located under CEO. This contradiction must be due to the consideration of large projects, for mammoth projects it seems essential to include the counsel of CEO while deciding on quality related aspects, while for relatively small projects Vice President and quality control department can manage the same. These statements suggest that it is most appropriate for quality control department to report directly to the vice president, but if required it is always preferred to refer the Chief executive officer.

From the potential model and the respondents analysis it is comprehended that, in the hierarchy of reporting, the CEO will occupy the level-I, followed by the Vice President at the level-II of the hierarchy and finally Quality Control Manager at the level-III. The key working personnel's in the department namely QA/QC managers, Quality Inspectors, Trade Engineers will work under the Quality Manager. Figure 4.8 depicts the pictorial representation of the best location of the Quality Control department in the hierarchy of contractor organization.

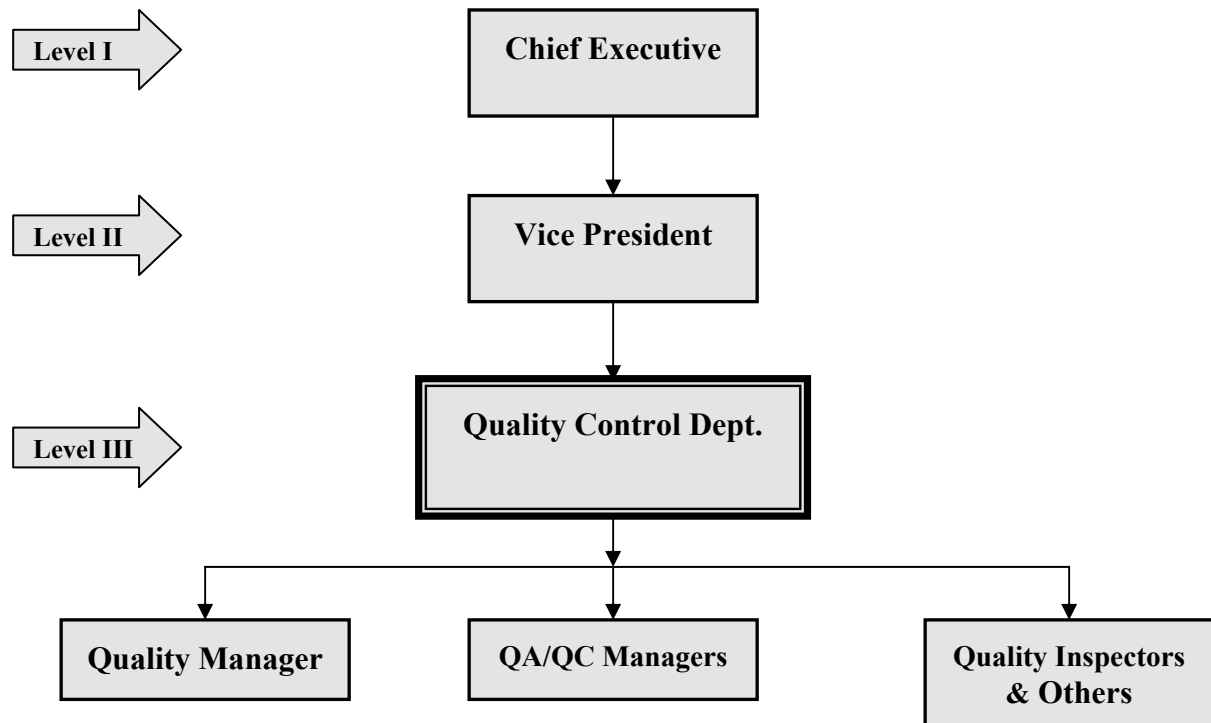


Figure 4.8: Best Location of Quality Control Department

III. Key Personnel's

The literature analysis on organizational aspects of contractor's quality control department suggested that Quality managers, Quality Inspectors, and the QA/QC managers are the key personnel's liable for the quality related aspects. These facts are strongly advocated by the expert's opinion of the same.

Almost all the respondents articulated that quality control department is headed by the quality Manager. Quality managers take charge of the activities, provide directions, and with their leadership skills deal with all the employees to maintain the momentum. The participant's responses, in concurrence with the potential model suggest that Quality Manager is the key personnel in the department.

The responses also suggested that Quality Inspectors and the QA/QC managers are other key personnel responsible for construction quality. Quality inspectors evaluate each stage of project execution on the site and along with QA/QC managers report the development to the senior manager. In addition to aforementioned personnel the experts also advocated for Trade engineer and Construction manager as the important player in quality control aspects.

Among the noteworthy comments issued by the interviewed experts include that, for having better quality edifice, lower ranked personnel play a major role and hence a proficient contractor should incorporate and give deserved privileges to those personnel's. They further mentioned that construction quality control is company-wide effort that requires everyone in an organization in an effort to improve the performance. Successes of a contractor organization depends on overall contribution from all the key personnel's.

IV. Quality Control Tools

Employing the latest tools has always been accepted as a gateway for successes. Potential model of quality control department suggest that there are as such no specific software's related to quality control. This information is strongly supported by the experts review on the quality control tools which suggest that as such there are no renowned software's or any specific tools for the same. However the potential model and the most of the experts review supported the fact that CAD tools are effective as they help in minimizing rework. This response suggest that CAD drawings presents the specifications

very eloquently, which helps in mitigating the errors and subsequently minimizing the costly task of rework.

Some of the experts also advocated for adopting “Industry standards and related documents such as NEC code, SAES, etc”. The aforesaid feedback from the experts suggested that software technology, and other tools for quality control are absent to a greater extent in construction.

V. Links with other Departments

Attaining high quality edifice is the first priority of Quality control department of every contractor firm. For achieving the same, along with other organizational aspects contractor quality control department should have good links with other departments in the contractor firm as mentioned in the potential model of this study. This hypothesis is strongly supported by the fact that almost all the participating industry professionals and academicians strongly advocated that quality control department should have good links with “Planning & Scheduling”, and “Construction safety” counterparts. These reviews suggest that quality aspects do have their impression on the duration of the construction activities, a well finished edifice consumes more time compared to a average quality structure. Hence it can be comprehended that there should be good links between Quality control and planning, Scheduling department.

Further eighty percent of the industry professionals and 60 percent of the academicians advocated for links between quality control department and “Cost estimation” counterparts. The inconsistency in the response of academicians seems to be because the participants feel that quality department can carry on the work without the assistance of cost estimation department.

Along with the aforementioned, some of the expert contractors and academicians articulated that quality control department should also have positive relations with Procurement/Purchasing department and Operations department. This is expressed by the fact that the procurement department provides the quality department with the raw materials of defined specifications.

VI. Quality Management Program

A quality management program is a document or set of documents that describe the standards, quality practices, resources and processes pertinent to a specific project. Based on the potential model it was noted that each contractor should develop his own Quality Management program, which should describe the Quality mission, working procedures, Quality goals and other relevant details which help in attaining overall better quality edifice. This information is comprehended from the responses of experts contacted, almost all the experts including the Academicians and the Contractor professionals either

agreed or strongly agreed about the fact that every contractor irrespective of size, should maintain his own Quality management Program.

Almost all the participants contacted agreed or strongly agreed that quality management program should include details about “Quality Culture/Mission Statement”, and the “Quality Goals”. Quality culture/mission statement seems to be important component as to produce edifice and give service of high standards, a quality culture or mission should be set and applied to all the activities. Where as quality goals seems to be important as it motivates when working towards some worthwhile goal and seeing progress against that goal. Hence these components can be considered as very important.

The participants also suggested for “Emphasis on People” as an important component. This aspect seems to be very important as quality personnel is the individual who has the skills and knowledge to properly perform the task. A quality management program must foster the training and development of such individuals.

The experts further added that Quality management program should particularly speak about the “procedures of attaining quality”, as they describe a establish system to achieve the same. The expert contractors cited an encouraging fact that the major mammoth firms in the Saudi Arabia maintains there own Quality Management Program.

VII. Certifications

This section of the model identifies the quality standards whose certification will be helpful to the contractor. Quality standards are the established benchmarks of quality that are being taken as role model by many in industry to evaluate their performance. The potential model suggested that, the contractor firms should follow certain quality standards and get quality certifications to eliminate errors in the constructed facility and to receive competitive edge in the industry.

Ninety percent of the Academicians and industry professionals advocated for the ISO9000 certification as the fittest for the efficient functioning of the quality control department. This suggestion seems to be based on the fact that ISO9000 certification gives the clients an assurance that the quality of the product meets their requirements. ISO9000 certification also provides the contractor firm a qualification edge to participate in bidding. Hence the importance of these certifications can be comprehended. But however seventy percent academicians and 60 percent of contractor professionals remained neutral over obtaining “Malcolm Baldrige National Quality Award”, certification. This opinion must be because of the complexities surrounding this certification and also because of the deficiency of information about the same.

The experts review on certifications revealed a very interesting fact about the construction industry in Saudi Arabia. A lot of the Saudi contractors follow the standards as per Saudi Aramco, SEC (Saudi electrical company), and the SABIC (Saudi Arabian Basic Industries corporation), to construct their edifice.

VIII. Quality Control: Best Practices

In Addition to the various organizational aspects which facilitate the contractor's quality control department to function efficiently, the potential model suggested several paramount practices based on literature analyses which are considered beneficial. This section of the model presents some of the paramount practices of quality control department.

Majority of the respondents reckoned that “quality-related decisions of the client have to be made prior to the start of the construction”, as this practice sets the tone for the quality work right from the conceptual stage. This is also important because, based on these specifications the cost and schedule can be confirmed.

Further, Eighty percent of the industry professionals or academicians rated the following practices very important or extremely important for forming a benchmark quality control department, “maintaining a well compiled Quality management program”, this practice is already established in the previous sections which suggest that quality program is essential as quality standards always change and hence a well maintained program will immensely assist the personnel.

The participants also suggested for practices including “Implementation of the TQM” program, training program for “newly hired and senior employees”, Quality control department should “communicate Quality goals & success” to all the employees. Training of employees seems to be considered a good practice as well qualified and knowledgeable personnel are necessary to satisfy all the quality requirements. Whereas considering communication of quality goals and success as best practice suggest that, it serves as a source of inspiration for the all the personnel to work for a target.

Many of the participants also ranked the following practices as extremely important or very important, “Quality control department should require its staff to participate in a training program”, the contractor firm should be “aware of the ISO9000 requirements”. Hence these practices can be considered as a good technique of improving quality standards of the firm. Table 4.1 depicts the suggested best practices for quality control department, comprehensively.

Summary of Quality Control Department

The figure 4.3 presents the summary of the organizational aspects essential for the efficient functioning of the contractor's quality control department.

TABLE 4.3: Organizational Aspects of Quality Control Department

ORGANIZATIONAL ASPECTS OF QUALITY CONTROL DEPARTMENT		
Key Functions	Location in the Organization	Key Personnel
• Assuring conformance to specifications	First Level of the Hierarchy: CEO	• Quality Managers
• Implementing Quality control program	Second Level of the Hierarchy: Vice President	• QA/QC Managers
• Certification of personnel such as suppliers, permit receivers, equipment operators	Third Level of the Hierarchy: Quality Control Department	• Quality Inspectors
• Minimize the errors in the constructed facility		• Trade Engineers
• Providing competitive edge in the industry		
• Improvement of procedures		
• Minimizing rework		
Quality Certifications	Quality Control Tools (Software's)	Links with Other Departments
• ISO9000 Series	• CAD tools, as they minimize rework	• Planning & Scheduling
• Saudi Aramco standards	• Industry standards and related doc. Such as NEC code, SAES etc.	• Construction Safety Department
• Sabic and SEC standards	• Other Suitable Software's & Tools	• Cost Estimation
		• Procurement
		• Operations
Key Contents of Quality Management Program	Quality Control: Best Practices	
• Quality Culture/Mission Statement	• The quality-related decisions of the client have to be made prior to the start of construction, as they set the tone for type and function of the construction.	
• Quality Goals	• The quality department shall require its staff to participate in a training program	
• Emphasis on People (Employee Involvement)	• Contractor firm should have full-time person(s) dealing with quality-related systems for their practice	
• Quality Control procedures	• The Contractor firm should be ISO certified and should be aware of ISO9000 requirements	
•	• The Contractor organization must have a written Quality Plan, system or program	
•	• Implementing TQM, training program for newly hired and senior employees	
•	• Quality department should, communicate Quality goals & Success to employees	

4.3.4. Construction Safety Management Department

Safety is a core for successful functioning of a contractor firm, as it guards the firm from internal and external litigations. In this research Safety management comprises one of the four departments, whose organizational aspects have been benchmarked.

Based on extensive literature analysis presented in Chapter-II of this research, the key organizational aspects of Construction Safety Management department were identified. figure **4.9**, clearly depict the key organizational aspects. These organizational aspects were further classified to shape a comprehensive model, each of which are explicitly illustrated below.

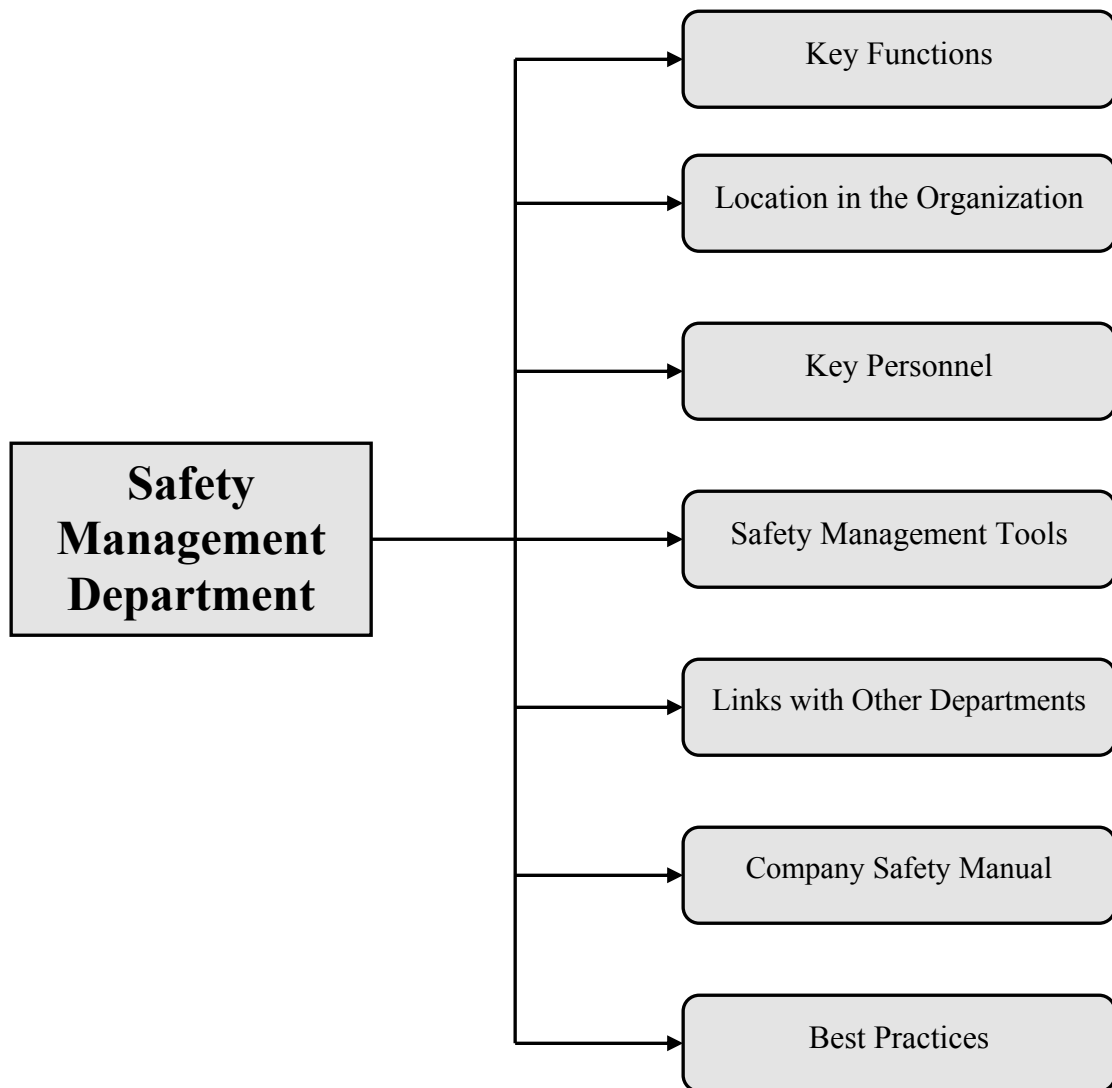


Figure 4.9: MODEL: Organizational Aspects of Safety Management Department

I. Key Functions

This section of the model identifies the key functions of the contractor safety management department. Key functions of the contractors Safety Management

department are the main objectives essential to shape the overall contractor firm work efficiently and flourish in the construction industry.

The potential model suggests that construction safety management department is a functional element of contractor firm and hence constitutes many objectives. Academicians and industry professional's opinion about the key functions suggest that both shared parallel ideas. All the professional experts strongly advocated for "Humanitarian concerns", as the primary objective of the safety management department. This review evidently suggests that safety of the workforce is very essential in construction business. The reason for the concern seems to be the fact that construction industry has been plagued with one of the highest rates of the accidents among all other industries.

Among the other significant functions of safety department, almost every participant ranked for "To build up company safety image". Company safety image is an important function and expert review indicates the marketing strategy of the contractor firms to build there image in the competitive industry. This suggests that a company with better safety record is more likely to acquire a project than an unsafe firm. Further eighty five percent of the experts advocated for "Minimizing direct or indirect costs of accidents" as one of the key functions. The opinion of minimizing cost as key function is strongly supported from literature analysis which suggests that construction firms expend large fraction of their expenditure on post accident activities. Accident on construction site

swell the indirect cost as these mishaps results in project disruptions, eventually affecting the cost.

Some of the experts advocated for few other key functions along with the aforementioned functions namely, “Implementing client approved safety and loss prevention program”, “To satisfy legal requirements”, and to “Reduce project disruptions”. These functions suggest that along with humanitarian and cost concerns the safety management department is also liable to implement the client safety and loss prevention programs and hence satisfying the legal requirements.

II. Location in the Organization

This section presents the most fitting location of the safety management department in the hierarchy of the firm. Location of a department in the overall organization structure of the firm suggests its hierarchy of reporting and communication with the officials above and under its level.

Participant's opinion was asked about the best location of the Safety Management department in the contractor organization, Majority of the experts articulated that it is most fitting for Safety Director, to report the safety aspects directly to the Chief executive officer of the organization. This information seems to be based on the fact that safety and security are very important and confidential attributes of a firm and CEO's appraisal is vital. But two industry professionals and equal number of academicians expressed that

along with CEO, the safety director can also consult the vice president of the firm. Hence, the overall responses suggest that safety director should report directly to the chief executive officer however the vice president can also be consulted if required.

Therefore from the potential model and experts vision it is comprehended that, in the hierarchy of reporting for Safety management department, the CEO will occupy the level-I, followed by the Safety director at the level-II of the hierarchical ladder. Safety manager, Safety supervisor, Site engineers, Foremen and other personnel's will work under the Safety director. Figure 4.10 portrays the best location of the Contractor Safety management department in a contractor organization.

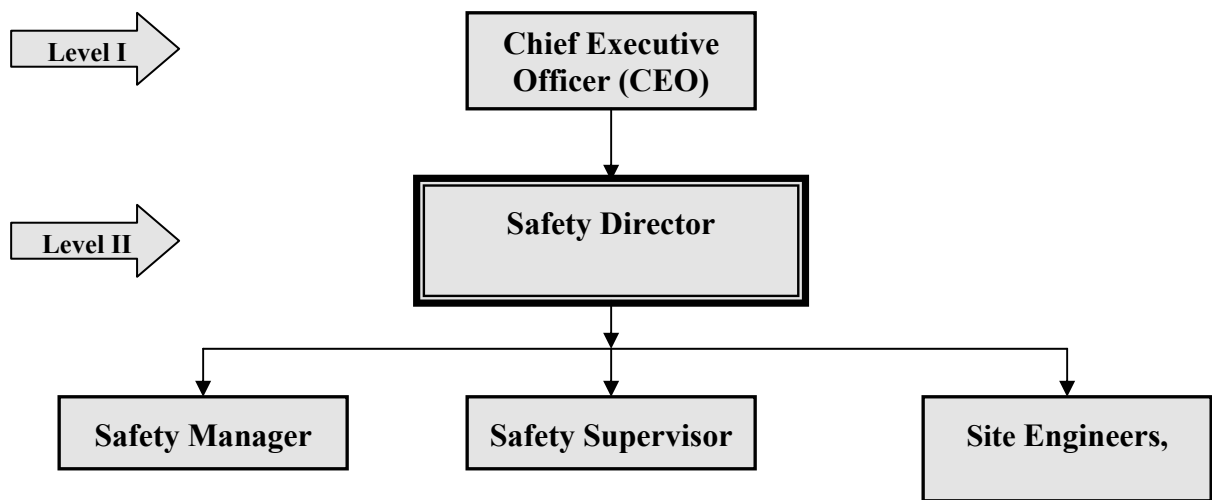


Figure 4.10: Best Location of Safety Management Department

III. Key Personnel's

Industry professionals and Academicians opinion on key personnel's responsible for safety management aspects of the various projects suggest that, Safety should be the most important concern of all the professionals involved in the construction process. The participant's reviews convey that contractor safety department is headed by the safety director. Safety director is important personnel and is responsible for instructing and training the entire staff, manage the safety organization and other major responsibilities. The safety director also coordinates with the subordinates and conveys the safety details to the higher authorities. Based on the said information, the safety director's rank as head of the department can be comprehended.

Among the other important personnel, almost all the contractor professionals and academicians designated Safety Supervisor and Construction Safety Manager as essential. The opinions suggest that safety supervisor is one of the key personnel as he supervises the work progress and will rectify any void in safety measures. Whereas the construction safety manager makes sure that adequate consideration has been given to site health and safety scrupulously. Further the expert's expressed that Site Safety Manager, Site engineers, Foremen and the Technicians also play a vital role in providing the safe atmosphere at the site. The academicians and industry professionals view on site safety managers is supported by the fact that site manager organize the site in such a manner that it is safe both for company employees and other persons who may be affected by the

same. Whereas the foremen and technicians are the important personnel on the site and their involvement in safety activities is essential for overall safety.

Among the prominent comments & suggestions from experts include that, each and every personnel irrespective of his rank is liable for the overall safety at the project site, hence the experts added that the safety achievements of the personnel's should be appraised.

IV. Safety Management Tools

Latest tools and software's are nowadays used in almost every area, particularly in construction. The participant's opinion in this research expressed an encouraging response which states that all the departments in contractor firm should employ latest tools for maximizing the efficiency of the overall firm.

However the industry professionals and academicians response about the tools of safety management were not encouraging. The reviews complimented the potential model of this research which articulated that there are no significant software's or tools specifically designed for safety management. But still majority of the experts agreed with the subsequent information mentioned in the potential model, which suggests that the safety department should employ some of the common tools like the Spreadsheets, the Word Processing & Graphics. Supporting the fact experts further added that spreadsheets

help to maintain an organized record of safety details. These facts indicate that though there are no particular software's but, the spreadsheets helps in effectively handling safety statistics. Word processing and graphics makes the work of safety personnel easy and accurate by preparing more communicative written information. Hence the use of these safety tools can be comprehended.

V. Links with other Departments

It is comprehended from the literature review, that the safety management is one of the core functions for the success or failure of the contractor firm. This section of the model identifies the departments with which safety management counterpart should maintain good relations. Participant's opinion strongly backed the information that for attaining the safety goals, along with the other organizational aspects the contractor safety management department should have good links with other counterparts within the firm. Eighty-five percent of the respondents agreed or strongly agreed with the fact that safety management department should have creditable links with Planning & Scheduling counterparts. This response seems to be based on the fact that projects with good safety performances are more likely to be on-schedule than those with poor safety performance. This is because many of the practices that contribute to a good safety performance also enhance the overall productivity of the project.

The responses also suggest that the safety department should also share information with, the Project Management, Quality control, and Cost estimation counterparts. This is

supported by the fact that high costs are associated with poor safety performances and lower productivity, it is in construction industries best interest to improve both, subsequently they will reduce the total cost and help overall quality.

VI. Company Safety Program

A written safety program is just as much a part of a contractors business as estimating and procurement. The potential model of this research based on the literature study recommended that a contractor organization should develop there own company safety program, which should explicate the important safety aspects. This is comprehended from the responses of participants. This section of the model presents the important components of contractor's company safety program.

Almost all the participants including the Academicians and the Contractor professionals either agreed or strongly agreed about the fact that every contractor irrespective of size, should develop his safety program, which shall speak about the Safety organization, Hazard control details, Medical and first-aid plans, Management support and directions, and the worker education details. These results must be based on the facts that articulate that management support is important it serves as a base to plan personnel selection, placement and indoctrination in such a fashion that safety concerns become a way of life for all the employees. Where as worker education is essential as new workers are most vulnerable to injuries, the soundest safety program begins with individual job training. Hazard control, medical and first-aid plans inform the workers safety techniques and about the arrangements for hospitals, doctors and other measures.

Some of the experts advocated for including “Environmental rules & regulations”, detailing the government upper limits for the same. The expert contractors also cited an encouraging fact that the major mammoth firms in the Saudi Arabia maintains there own safety program.

VII. Safety Management: Best Practices

Along with the various organizational aspects which facilitate the contractor organization to function efficiently, the potential model has cited some principal practices that are cosidered useful. Among the most prominent practices, ninetyfive percent of the experts expressed the need of “Site safety meetings for field supervisors”, approximately 15 min daily. Improtance of this practice amplifies the benefits of site safety meetings, safety meeting usually helps all the personnel to remind one another about the safety goals and also discuss the current site safety conditions. Hence this practice can be considered as very beneficial for overall safety performace of the firm.

Among the other best practices, the “Written safety policy & program”, and “Safety inspections” are rated as extremely important practice. As expressed in the above sections, that the written safety policy is an important element for over all safety behavior of the firm. Whereas safety inspections are essential as they improves the safety record of the construction company.

Ninety percent of the experts articulated for, “Communicating safety goals to all the personnel’s” as extremely best practice. Safety goals serves as a source of inspiration and provides a challenge to the personnel to improve safety performance. Further eighty-five percent of the experts expressed “Following OSHA safety rules” and “Training newly hired and promoted personnels” as some of the best practices to enhance the performance of the safety management department.

The experts also expressed that the construction safety & health related considerations should start at the design and planning stage. Some of the contractors also recommended for “Penalties for breaching safety rules”, and giving “Incentives to project team achieving safety goals” as best practices for successes of the safety department and the overall firm.

Summary of Safety Management Department

The table 4.4 presents the summary of the organizational aspects essential for the efficient functioning of the contractors' safety management department.

TABLE 4.4: Organizational Aspects of Safety Management Department

ORGANIZATIONAL ASPECTS OF SAFETY MANAGEMENT DEPARTMENT		
Key Functions	Location in the Organization	Key Personnel
• Humanitarian concerns	First Level of the Hierarchy: CEO	• Safety Director
• Minimize Direct & Indirect costs of accidents	Second Level of the Hierarchy: Safety Director	• Construction Safety Manager
• Build up company safety image		• Safety Supervisor
• Implement client approved Safety and Loss Prevention program		• Site Safety Manager
• Reduce project disruptions		• Foremen, Technicians & others
• To satisfy legal requirements		
Key Contents of Company Safety Program	Safety Management Tools (Software's)	Links with Other Departments
• Safety organization	• Spreadsheets	• Planning & Scheduling
• Management support & direction	• Word Processing & Graphics	• Project Management
• Worker education	• Other Suitable Tools	• Cost Estimation
• Hazard control details		• Quality Control
• Medical & first-aid plans		• Construction dept.
• Environmental rules & regulations		
Safety Management: Best Practices		
• Construction Safety and Health considerations must start at the design and planning stage	• Training program for newly hired or promoted foremen	
• The Safety department should hold site safety meetings for field supervisors	• Communicating safety goals to all the employees	
• It is recommended for contractors to follow OSHA safety rules	• Penalties for those who contravene safety rules	
• The project safety inspections have to be carried out	• Incentives for project team achieving safety goals	
• An efficient contractor firm must have its own written safety policy & program		
• A proficient contractor firm should conduct an orientation program for new hires		

CHAPTER FIVE

SUMMARY, CONCLUSIONS & RECOMMENDATIONS

5.1. Introduction

The research study is presented in five chapters encircling the whole research essence. This chapter presents the summary of the study, ultimately divulges the digest of major findings drawn from the study. The research findings are presented while considering the final model, and their interpretations are also briefly mentioned. The chapter also cites the appropriate current recommendations, which the researcher has developed based on the conclusions of the research study. Some recommendations for further studies in the same area were also indicated and suggested according to the perception of researcher.

5.2. Summary of the Study

The overall efficiency of contractor depends to a large extent on its organizational and working system. Hence, setting up a standard organizational system is essential for the successes of a contractor. The current research is a qualitative study that benchmarks the organizational aspects of the contractor's project management elements of Time, Cost, Quality control, Safety. There are many issues to deal with organizationally and at managerial levels when creating and benchmarking the organizational aspects of different

departments associated with contractor organization. This research identifies and attempts to benchmark some of the key organizational aspects. The aspects identified and studied include the Key functions, Best location in the organizational structure, Key Personnel, Tools to be employed, Links with other departments, Company manuals/Programs, Best Practices, Skills of the head of the departments and other related issues.

The research objectives are achieved in three phases firstly the key organizational aspects for the proposed departments were identified based on the relevant literature studies. Potential model of benchmark contractor was developed by further studying each aspect identified, based on the diligent analysis of pertinent literature in order to gain insight of the research theme. In the final stage the potential model was reinforced via expert opinion from the industry professionals and the qualified academicians within the kingdom of Saudi Arabia. The model was strengthened through the administration of questionnaire. Total of eleven (11) academicians and ten (10) contractor professionals contributed their expert reviews to strengthen the study.

Based on the organizational aspects and the key components constituting these aspects identified in potential model, this study presents a model benchmarking the organizational aspects of contractor in Saudi Arabia. The model intends to achieve the following:

- It is expected to be excellent source of reference for contractors in Saudi Arabia and worldwide.

- It will be a source of guidance for the deficient Contractors to recuperate their organization.
- It will assist the booming contractors to reassess themselves to gain competitive edge in the construction industry.
- It will be an excellent tool of education in academia.

5.3. Summary of the Results

This research benchmarks the organizational aspects of four project management elements of contractor. Each of these subjects brings value by helping to develop people or assisting in managing the department, but it is the combination of all of these issues that builds a truly successful organization. The following are the findings that can be comprehended from the study.

5.3.1. Cost Estimation Department

The following are some of the major findings about the Cost Estimation Department based on the model:

1. Determining the direct and indirect cost of the construction project is the key function of the cost estimation department, along with recommending projects to tender for and preparing bids for submission.

2. In the hierarchy of location in the organization structure, it is most fitting for cost estimation department to position itself directly under the vice president of the organization. However the Chief Executive officer can be consulted when required.
3. Cost estimation department is headed by the Chief Estimator. The Estimating staff, Quantity surveyors and other staff assist the chief estimator in generating the competitive estimates.
4. An efficient cost estimator should have traits including the knowledge of construction methods, material costs, construction trends, software skills, engineering design and other skills.
5. For generating competitive estimates, the department should employ prominent software like Timberline software or any other suitable software's.
6. For preparing realistic estimates, the Cost Estimation department should have strong links with Planning & Scheduling, Procurement, Quality Control, Safety, and finance counterparts.
7. The contractor should develop his own Estimating manual, which should explain, the overview of the estimating process, review of estimate requirements, planning the estimate, structuring the estimate, documenting the basis of an estimate, and also include a price bank, along with other essential details.

Some of the other findings from this extensive study are as under:

8. Construction contractors in Saudi Arabia continue to use conventional and traditional tools for cost estimation. Small size contractors seldom employ estimating software's, they are generally content with manual estimating techniques.

5.3.2. Planning & Scheduling Department

The following are some of the major findings about the contractor Planning & Scheduling Department:

1. Ensuring the completion of project on scheduling is the key function of the department. Among the other key functions include the ensuring continuous and unremitting flow of work without delays, clear comprehension of who does what when and how much, integration of entire work to make sure a quality project for the owner, Acquaintance of the scheduled times of key areas of the project, resource leveling, developing and updating the project plan and other functions.
2. In the hierarchy of location in the organization structure, the Planning & Scheduling department positions itself directly under the vice president of the organization.
3. Planning & Scheduling department is headed by the Chief planning & scheduling Engineer. The Project scheduler, Scheduling assistants, Project managers and the Field engineers contributes in efficient planning and scheduling of the entire project.

4. The Chief planning & scheduling engineer is expected to execute the duties like to Plan and schedule the entire project. Other duties including, preparing project P&S related procedures and guidelines, Progress monitoring, Management coordination and other necessary aspects.
5. The department should employ the software's like Primavera Project Planner P3, Microsoft Project or any other suitable software's to develop more profound and presentable schedules.
6. The critical path method and Gantt bar chart are the most suitable and efficient planning and scheduling techniques. Program Evaluation & Review Technique can also be employed depending upon the type of project.
7. For proficient functioning, P&S department should have good links with the Cost Estimation, Procurement/Purchase, Safety, Quality Control and Operations department.

5.3.3. Quality Control Department

The following are some of the major findings about the Cost Estimation Department:

1. The key function of the quality control department is Assuring conformance to specifications. Other important objectives are, to minimize rework, minimizing the errors in the constructed facility, providing competitive edge in the

industry, improvement of procedures, implementing quality control program and other functions.

2. It is most fitting for Quality Control department to position itself directly under the vice president of the organization. However the Chief Executive officer can be approached straight away when required.
3. The key personnel in the Quality control department are the Quality Managers, Quality Inspectors, Trade Engineers, and QA/QC Managers, along with other personnel.
4. The department should employ the techniques like CAD tools or any other suitable software's.
5. For producing better Quality results, the department should have good links with Planning & Scheduling, Safety, Procurement, and Operations departments.
6. The department should maintain written Quality program unfolding its Quality culture / Mission Statement, Quality Goals, Procedures and Emphasis on people.
7. For qualified functioning the department must acquire and practice certification from ISO9000 series. The contractors in kingdom can also follow the standards of Saudi Aramco, SABIC and SEC.

Some of the other findings of this extensive study are as under:

8. Major mammoth firms in the Saudi Arabia maintain their own Quality Management Program.

9. Most of the construction firms in the kingdom follow standards set by Saudi Aramco, SABIC and SEC.

5.3.4. Safety Management Department

The following are some of the major findings about the Cost Estimation Department:

1. Humanitarian concern is the main function of the department. The other key functions include minimizing the direct and indirect costs of the accidents, building company safety image, reducing project disruptions, and to satisfy legal requirements.
2. In the hierarchy of location, it is most fitting for Safety Management department to position itself directly under the Chief Executive Officer of the organization.
3. The safety department is headed by Safety Director. The Construction Safety Manager, Safety Supervisor, foremen and technicians are the other key personnel in the department.
4. For proficient functioning, the construction Safety department should employ the tools like Spreadsheets, Word Processing & Graphics and others techniques.

5. For efficient function, the Safety Management department should maintain good links with Planning & Scheduling, Quality control, Project Management, Cost Estimation, and the Construction departments.
6. Contractor should maintain his own safety management program, it should describe in detail the safety organization, hazard control details, management support and directions, environmental rules & regulations, worker education, and the company medical and first-aid plans.

Some of the other findings of this extensive study are as under:

7. Safety is an important concern, each and every personnel is liable for co-worker safety and overall site safety.

5.4. Recommendations

In the light of developed research model, it is recommended that the contractors adopt the suggested techniques and practices prescribed via the research model. The model identifies number of key organizational aspects for each project management element, accepting these procedures will help the contractor firms function fittingly.

Based on the findings of this research, the following are some of the important recommendations being suggested:

- The authorities in the kingdom, namely, the Ministry of Commerce, the Ministry of Public Works and Housing, the Engineering Committee, the Contractors Committee, the other concerned authorities are recommended to promote, preach, and encourage contractors to develop their standards & organizational working system.
- Contractor firms in the Saudi Arabia are advised to acclimatize to latest tools and software's available for the construction industry, to better the working system and match the competitive environment.
- The senior executives and other top management are supposed to be acquainted with the essential construction management tools. However a minimum computer literacy to the level of spread sheet is essential.
- Training of the personnel associated with the organization is essential aspect for competing in the competitive construction industry. In case of cost estimation department, only very competitive estimates have any probability of acquiring a contract, and hence well trained estimation crew is essential. Whereas the quality control is a continuous process from inspection to completion of the project, so all personnel involved must be educated and trained to achieve the quality goal. Similar holds good for other departments, hence the training of the personnel with respect to organizational requirements is essential.

5.5. Recommendations for Further Studies

This subject opens the door for a lot of future research. The following potential areas of studies, if explored, would provide increased validity to the findings of this research:

- Although much have been done on contractor prequalification and other areas related to contracting, very little has been talked about standardizing the ideal composition of contractor firm. Specially needed is the model describing the organization of the entire contractor firm.
- Since this study was limited to benchmarking the organizational aspects of Project management related departments of contractor, similar studies should be carried out on all the departments associated with contractor organization.
- An extensive study could be done on organizational aspects of every department separately, to include all the miniature details.
- The boundaries of the respondents could also be widened to include the experts from the whole Kingdom of Saudi Arabia.
- Similar to the model developed in this study, a model delineating every aspect of an ideal contractor can be established.
- Experts systems could be developed that help the contractors in evaluating their working system, covering all the departments of contractor.

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APPENDIX - A

VITA

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